Power and The Engineer

Vol. 32 NEW YORK, NOVEMBER 1, 1910 No. 44

AS a general proposition all of the coal is not taken from the mines. Often that coal which is allowed to remain is left in such condition that to get it out at some subsequent time will entail much expense which by a little foresight in the first place could be avoided.

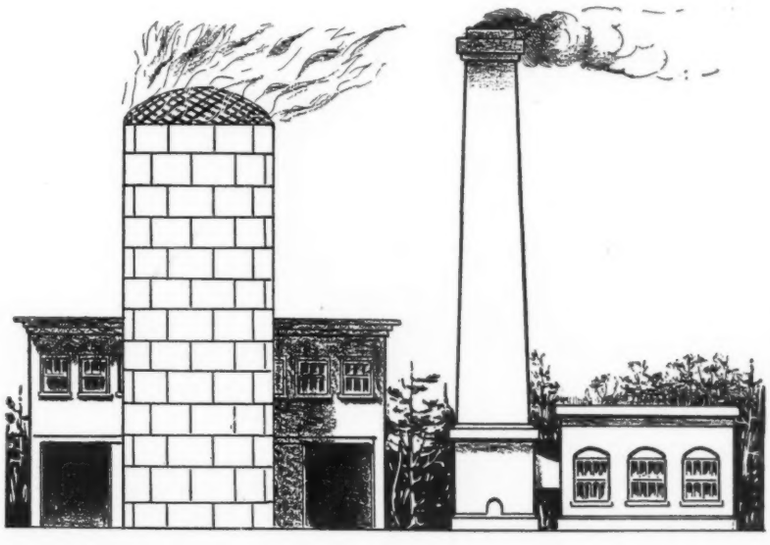
Some coal is put into beehive ovens and converted into coke. The heat, the combustible gas and the byproducts, tar and ammonia, which result from the conversion of coal into coke, are utterly wasted.

At many large lumber-manufacturing mills, the disposal of sawdust and waste wood is a source of actual expense. At some mills the waste products are burned in immense incinerators. As much of the waste wood as is needed is used in the boiler house to generate steam. The rest goes into the destructor to be burned, in spite of the fact that alcohol could be distilled from the wood and the spent wood utilized to furnish heat for the still.

This is not conservation.

The pity is that manufacturers find it profitable to employ such wasteful methods, for the time is in sight when the scarcity of at least some raw materials will amount almost to a positive hardship.

That the rapid depletion of the natural resources of the nation is a serious question is made evident by the fact that the United States Government has appointed a commission of able men who are devoting earnest efforts to the problem of how best to conserve our stores of raw materials. In 1908 the President convoked the governors of all the States to consider ways and means of furthering conservation. The Second National Conservation Congress has but recently adjourned.



These things are as they should be, and commendable.

However, true conservation cannot be accomplished by commissions and congresses. It cannot be furthered materially by the withdrawal of coal and mineral lands or by the control of water-power sites by the Government. The people of the Nation must be the conservators in the last analysis.

Genuine conservation can be practised by everyone, for, reduced to the simplest terms, conservation means *best use*. In the instances cited in the opening paragraphs, best use means longer endurance of the supplies of raw materials coupled with greater ultimate profits from their utilization.

With the individual, best use of the materials which are employed and best use of his abilities make a man efficient.

In steam engineering, conservation of the best kind can be practised right at the throttle wheel and the fire door. A properly adjusted and lubricated engine requires less steam than one of the other kind. Less steam means less coal, other things being equal. And with intelligent firing, the required amount of coal is still further reduced. Then there are other factors too—many of them—all of which boil down to man's use of his intelligence.

Therefore you are urged to be a conservator to boost your own as well as the common cause.

Power Plant of McCormick Building

By Osborn Monnett

This power plant is so designed that continuity of operation is a practical certainty. Ample room, automatic apparatus and instruments and carefully worked out details, such as the piping color scheme, make for favorable operating conditions.

A visit to the subbasement of the new 20-story McCormick building, on the corner of Michigan avenue and Van Buren street, Chicago, discloses a steam plant of the most modern character. It is evident that no expense has been spared in equipping the plant in the most substantial way and providing everything necessary for the service requirements in a building of this kind. The designers were able to use plenty of room for the power plant, resulting in an absence of the usual crowded conditions found in so many plants. The engine-room floor level is about 35 feet below the street. The decorations are of a plain character. The machines are finished to match the general decoration scheme and neatly striped. The foundations are faced with white enamel brick which, in connection with the "Granito" floor, consisting of a mixture of cement and marble chips, ground and smooth, polished, gives a finished appearance to the room.

In the layout of the plant, as seen in Fig. 1, the electrical generating units have been ranged on one side of the room, while on the other are located the pumping equipment and various auxiliary apparatus.

Boiler Room

The boiler room, which is at a level 10 feet below the engine room, contains, as shown in Fig. 2, three 250-horsepower Heine, double-drum water-tube boilers,

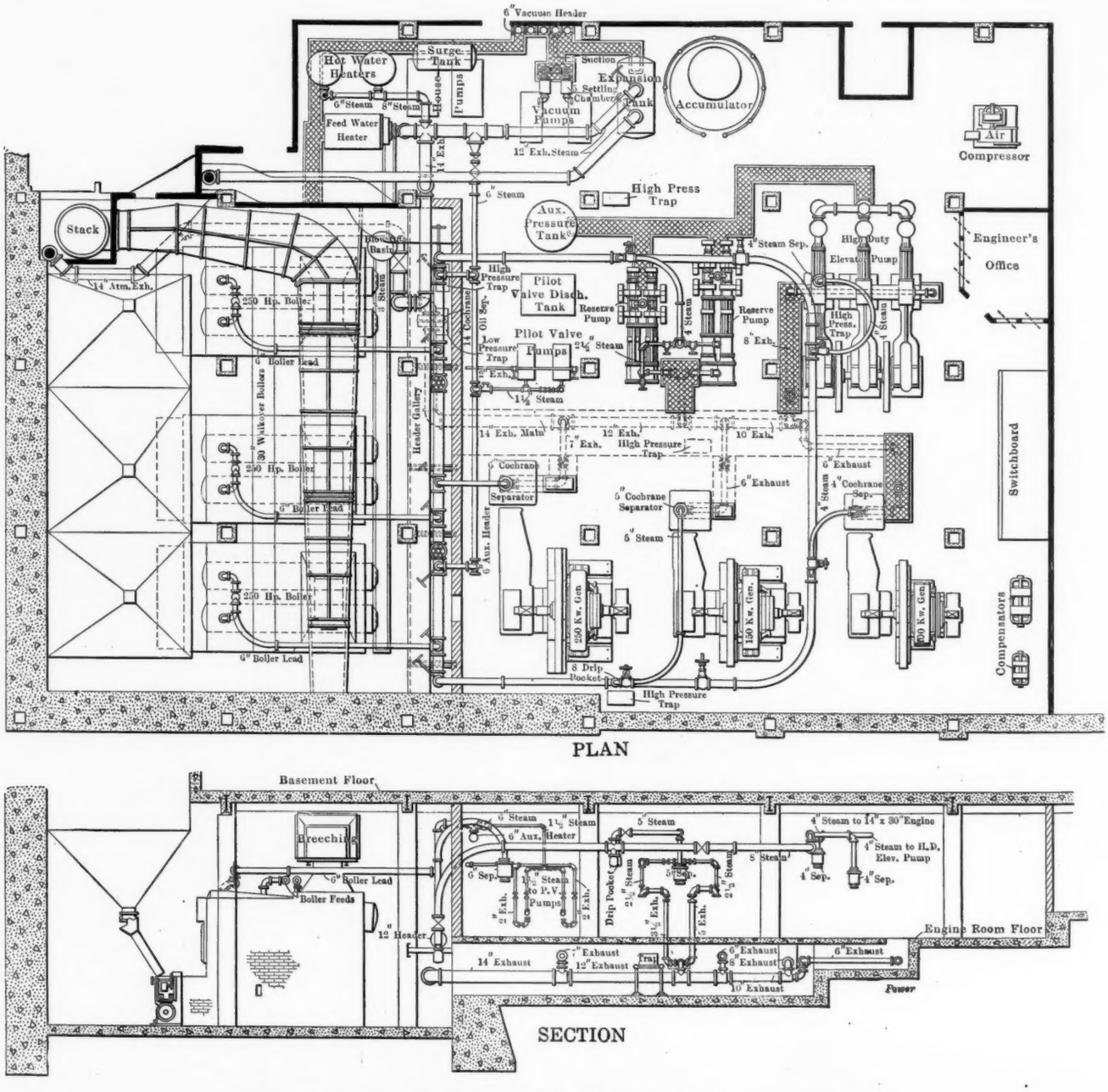


FIG. 1. PLAN AND SECTION OF POWER PLANT IN MCCORMICK BUILDING

fitted with McKenzie chain-grate stokers having 60 square feet of grate surface each. The stokers are equipped with individual motor drives and variable speed control. The boilers are fitted with

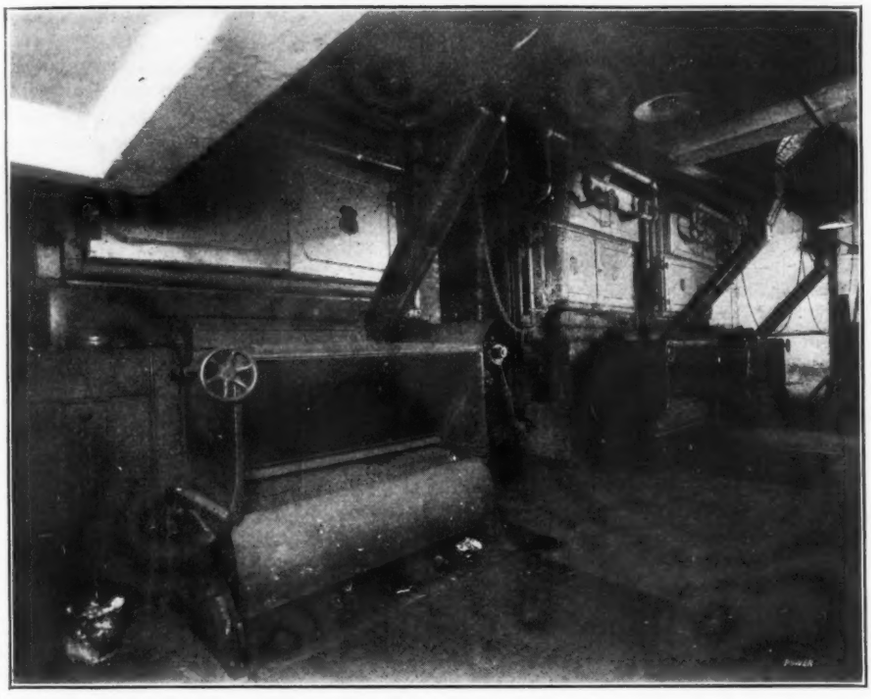


FIG. 2. BOILER ROOM OF MCCORMICK BUILDING

a standard equipment of Bayer soot blowers. A Spencer damper regulator in the main uptake controls the draft according to the steam pressure. It is interesting to note that the damper regulator is to be electrically connected with the stoker drives, in order to vary the rate of feeding the fuel in accordance with the demand for steam. This should result in ideal furnace conditions and act as an additional safeguard against smoke with variable loads. To keep check on the matter of combustion, an Eddy smoke recorder has been installed, to give a continuous record of stack conditions at all times.

Coal is delivered from wagons in the alley, dumped into the bunkers, which have a capacity of 280 tons, whence it is spouted to the stokers in the ordinary way. The ashes are removed from beneath the stokers by hand, wheeled to Illinois Tunnel Company's cars through a connection which taps into the boiler room and removed underground through the tunnel. For boiler feeding there are two 10 and 6½ by 10-inch vertical Blake pumps, installed on the boiler-room wall, feeding from a 1000-horsepower Cochrane open heater under a head of about 10 feet. The feed lines extend to manifolds between the boilers, from which branches lead to the boilers. The feed water is introduced in the front of each head. Could water columns and feed-water control maintain the water level. There are bypasses on the manifolds so that the feed water may be controlled by hand when necessary.

PIPING

An elaborate system of steam piping has been worked out to insure against breakdown. By referring to Fig. 1, it will be evident that the high-pressure steam lines have been laid out on the loop system. The main steam header, 12 inches in diameter, lies behind the boilers about 8 feet above the boiler-room floor. An iron platform is conveniently located, making the header easily accessible for repairs. Into the header drop 6-inch connections from the boilers, and out of each end section rises an 8-inch line to the loop in the engine room. Two gate valves divide the main header into three sections, the middle one having a connection direct to the largest generating unit. An auxiliary header extends along the engine-room wall, with pump connections and also a live-steam bypass to the heating system. This auxiliary header taps into each end of the main header and can be supplied from either end at will. By means of the piping arrangement, as shown, the entire engine-room loop may be supplied by either end of the main header or the middle section can be utilized alone for electric power and pumping service. Any section of the header may therefore be cut out for repairs or isolated for testing the performance of any one boiler or engine unit. Similarly, in the engine room, the loop is well provided with gate valves, enabling any section to be taken out of service without interrupting the operation of the plant. Branches to the several engines come out of the top of the loop and are provided with long-sweep bends. The piping is extra-heavy weight with screwed flanges, peened on the inside, the flanges being made up with Tauril packing. Crane-tilt traps take care of the condensation. Cochrane separators are used throughout at the throttle valves and also on the rims of piping.

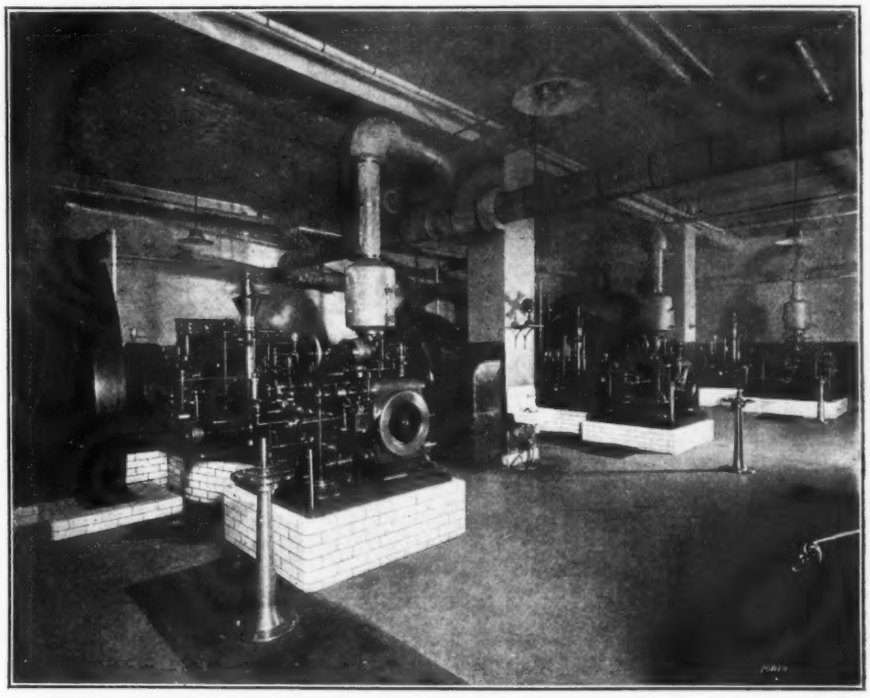


FIG. 3. GENERATING UNITS IN ENGINE ROOM OF MCCORMICK BUILDING

All valves in the plant are Lunkenheimer, the large gate valves on the steam-header system being provided with bypasses. All valve stems are packed

with Root's high-speed metallic packing. This packing is also used on every steam-piston rod in the plant.

The exhaust piping is unusually accessible; the several exhaust lines from the engines lead into a tunnel under the main aisle of the engine room, where any pipe may be worked on without interfering with any other. The tunnel leads to the boiler room, where, after passing through a 14-inch Cochrane oil separator, the exhaust connection is made to the heater, the heating system and the atmosphere, in the usual manner.

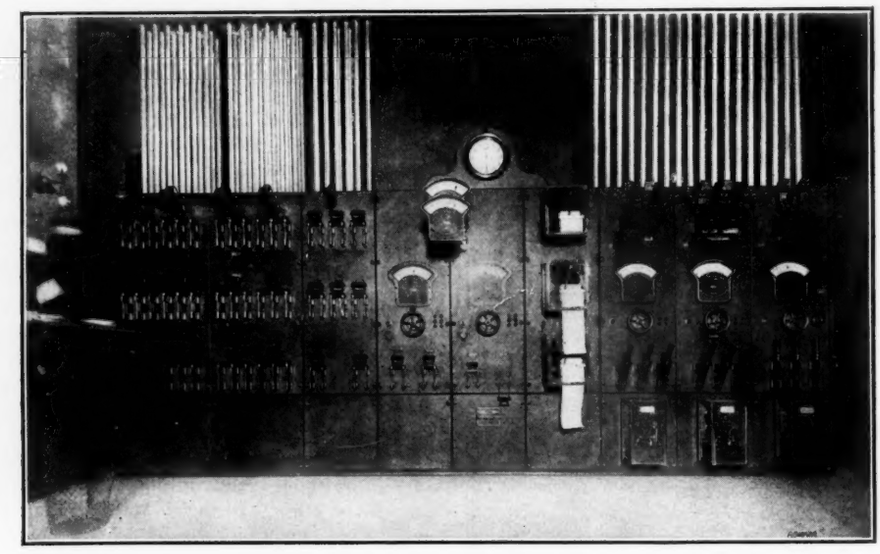


FIG. 4. THE MAIN SWITCHBOARD.

GENERATING UNITS

Fig. 3 gives a general view of the electrical side of the engine room. Here are installed three Filer & Stowell Corliss engines, direct connected to Crocker-Wheeler generators. The units have a capacity of 100, 150 and 250 kilowatts, respectively, each running at 110 revolutions per minute. The smallest engine has a 14x30-inch cylinder, the next in size a 16x36 and the largest, a cylinder 18x36 inches in size. Hills-McCanna force-feed oil pumps are used for valve lubrication on these engines as well as on all steam pumps, the main-valve oil supply being kept in a Bowser oil-storage and measuring tank. The engine oiling system, while of the standard gravity-flow type, has some features worthy of note. Waste oil is caught in a settling tank located in the tunnel under the engine-room floor, from where it is drawn to a White-Star filter. The purified oil is pumped to an elevated pressure tank in the engine room, by a small air-operated Knowles pump.

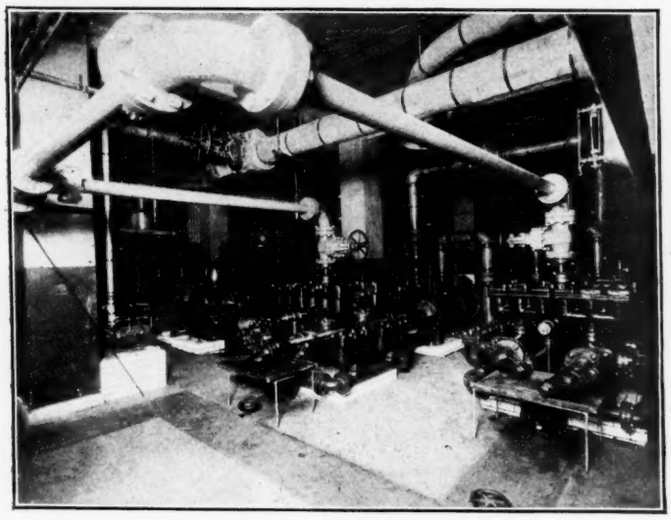


FIG. 5. THE ELEVATOR PUMPS

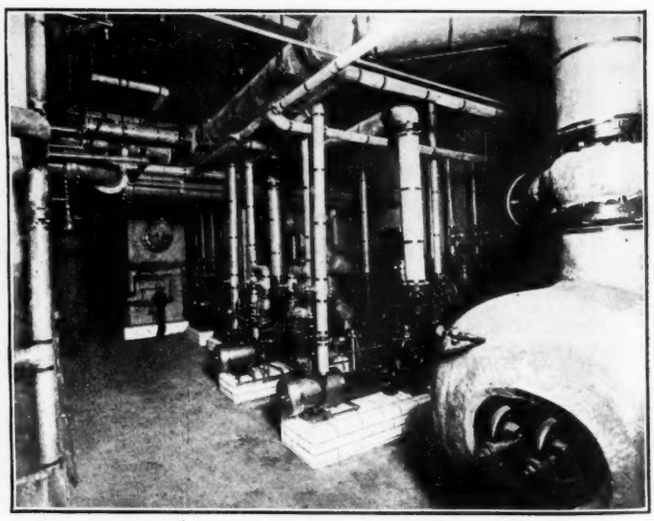


FIG. 6. HOUSE AND VACUUM PUMPS, FEED-WATER HEATER AND EXPANSION TANK

It was found that in hot weather the oil supply was excessively warm, sometimes reaching a temperature of 140 degrees, causing the bearings to run hot. The expedient was adopted, therefore, of passing the oil supply through a double-pipe cooler consisting of a piece of 1-inch pipe inside a 2½-inch pipe through which a small amount of city water is circulated.

From the cooler on, the oil-supply pipes are lagged with regular pipe covering to keep the heat of the engine room out, and the oil now reaches the bearings in hot weather at a temperature not greater than 90 degrees. Nugent telescopic oiling devices are supplied on eccentrics, wrist-pins and wherever necessary.

Current is delivered by the generators at 225 volts and distributed throughout the building by a three-wire system, using balancer sets, the lighting being done at 110 volts while the power circuits are of 220 volts pressure. Each generator panel carries a wattmeter. On the meter panel are carried a Westinghouse graphic recording voltmeter and two ammeters of similar type, one for lighting and one for power. The switchboard itself, a view of which is shown in Fig. 4, is constructed of black slate. The back of the board is inclosed in substantial wire netting, making it impossible to come in contact with the busbars. Every circuit coming to or going from the board is in iron-armored conduits and proof against mechanical injury.

PUMPS

All of the eleven elevators in the building are hydraulic; nine are for passenger service and two for freight. They are of the Otis inverted-plunger type, operating under a pressure of 800 pounds per square inch and having a weighted accumulator and ram floating on the system. For carrying the regular elevator load there is one Laidlaw-Dunn-Gordon high-duty three-cylinder compound pumping engine provided with 16 and 30 by 30 by 24-inch cylinders and 5⅝-inch water plungers, while held in reserve is a 14 and 20 by 18 by 5½-inch tandem-compound pump and one simple 16 and 18 by 5½-inch pump, both of the pot-valve

type and of the same make as the high-duty unit. The remainder of the elevator equipment is of standard Otis design for this type of machinery. Two 6 and 4 by 6-inch Laidlaw pilot pumps maintain a pressure of 200 pounds on the elevator pilot-valve system, these latter operating at this pressure rather than at the full 800-pound pressure of the main hydraulic line.

Fig. 6 illustrates the remainder of the equipment in the engine room. In this corner are located two 10 and 7 by 10-inch Blake house pumps delivering water to tanks on the roof, and two Knowles 8 and 12 by 12-inch vacuum-return pumps working on the Van Auken system. A 12-inch exhaust riser extends to the roof and the steam is supplied to the radiators on the down-flow principle. Two Baragwanath heaters are also connected to the exhaust-steam line to furnish hot water through the building. On the boiler-room level is a sump in which all drains are collected and elevated to the sewer by means of Yoeman's electrically driven ejectors, one Worthington centrifugal pump direct connected to a 6x8-inch Marine Iron Works vertical engine, being held in reserve.

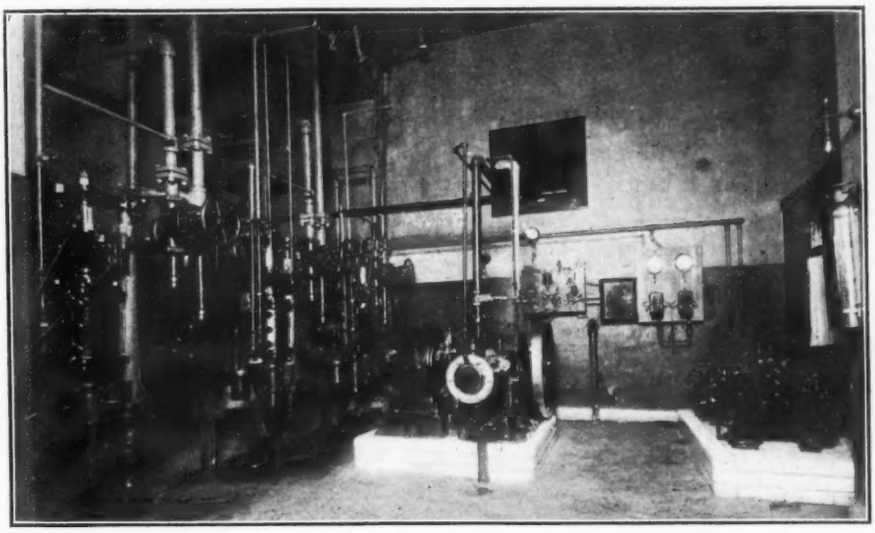


FIG. 7. ELEVATOR CONTROLS AND AIR COMPRESSOR FOR CLEANING PURPOSES AND THERMOSTAT SYSTEM

COLOR SCHEME

An elaborate color scheme has been adopted in this plant following the system outlined in the July 26 issue of POWER. Colors have been selected which will wear well and not change by heat or age sufficiently to be mistaken. The colors used are red, black, green, brown, white and yellow. The idea has been not to paint the entire lines of piping in different colors, but to paint markers on the various pipes in prominent positions where they will show to the best advantage. The marks are made in arrowhead form, the point of the mark indicating the direction of flow.

The high-pressure steam, reduced-pressure steam and exhaust-steam lines, which obviously are the most important, all are marked with black; this color being unmistakable, the distinction in these three cases being a wide mark for the high-pressure lines, two narrow ones for the reduced-pressure lines and a single narrow mark for the exhaust lines. Similarly, pipes for different auxiliary services are marked, as shown in detail in the article referred to previously. With this color scheme it is possible to tell at a glance what is inside of any pipe, and the direction of flow. It is easily and cheaply installed and is a great convenience to the operators.

Do We Waste 95 per Cent. of Our Fuel?

A correspondent writes: "In reading a book which has recently appeared, I came across this statement which astounded me: 'But 5 per cent. of the potential power residing in the coal actually mined is saved and used. For example, only about 5 per cent. of the power of the 150,000,000 tons annually burned on the railroads of the United States, is actually used in traction. Ninety-five per cent. is expended unproductively or is lost. In the best incandescent and electric-lighting plants but one-fifth of one per cent. of the potential value of the coal is converted into light.' This may be true, but it seems incredible that in the conversion of potential into mechanical energy there should be such an enormous waste. What are the facts in the case?"

The correspondent's statement is true to this extent and in this way:

A British thermal unit is the amount of heat necessary to raise a pound of water one degree Fahrenheit, and is equivalent to 778 foot-pounds of work.

A pound of good coal may contain somewhere around 14,000 B.t.u. or the equivalent of

$$14{,}000 \times 778 = 10{,}892{,}000$$

foot-pounds.

A horsepower is 1,980,000 foot-pounds per hour.

An engine which could produce a horsepower for an hour with the consumption of one pound of coal would therefore convert into work,

$$\frac{1{,}980{,}000}{10{,}892{,}000} = 0.18$$

or 18 per cent. of the energy inherent in the fuel.

The ordinary engine takes five or six times this much.

There is a great loss in the conversion of energy, after the engine develops it, into light.

On the other hand, we are limited by our environment and conditions. We can get, with exceptional boiler work, 80 per cent. of the energy of the fuel into steam, but an ideally perfect heat engine would take out of this steam only a fraction represented by

$$\frac{T - t}{T}$$

where

T = Absolute initial temperature or high heat level;

t = Temperature of rejection or low heat level.

Heat is convertible into mechanical energy only by working it from a higher to a lower temperature level. To get all the heat into energy the heat must be worked to the level of absolute zero. To take an hydraulic analogy, each pound of the water in a pond 1000 feet above the sea level has in it, due to its elevated position, 1000 foot-pounds of energy, which it will give up if allowed to fall to the sea. But if the configuration of the country is such that the greatest fall obtainable in the vicinity of the pond is 100 feet, an ideally perfect turbine could only get 100 foot-pounds out of each pound of the water, or 10 per cent. of its inherent energy.

$$\frac{H - h}{H} = \frac{1000 - 900}{1000} = 0.10$$

or 10 per cent.

The absolute zero of temperature is 461 degrees below the zero of the Fahrenheit scale. We live up on the plane where the temperature is around 70 degrees Fahrenheit, or

$461 + 70 = 531$ *degrees absolute.*

The cooling water which is used in the condensers will average about 35 or 40 degrees in the winter and 70 or 80 degrees in the summer. Unless we use impracticable quantities of it we must let it heat up to 100 or 110 in absorbing the heat necessary to maintain the lower temperature level, which is therefore fixed at not below 100 degrees Fahrenheit, or 561 degrees absolute.

The temperature of 180 pounds steam is 373 degrees Fahrenheit;

$373 + 461 =$ *degrees absolute.*

The efficiency of an ideally perfect engine under these conditions would be,

$$\frac{T-t}{T} = \frac{834-561}{834} = 0.33$$

or 33 per cent.

Even with a 100 per cent. boiler and engine efficiency we could then under our conditions (and with our present knowledge) get, with an engine working between these limits, only 33 per cent. out of the fuel. With 80 per cent. boiler efficiency and a perfect engine we might readily get

$0.80 \times 0.33 \times 100 = 26.4$ *per cent.*

Steam engines are built which get out 60 odd per cent. of the energy due to the fall between attainable temperature limits, say,

$26.4 \times 0.65 = 17$ *per cent.,*

which comes pretty nearly to the 18 per cent. which, as was shown at first, would be represented by the pound of coal per horsepower which is in sight and has been attained by some exceptional engines.

The gas engine with a wider temperature range actually attains between 25 and 30 per cent.

If a *perfect* engine would only realize 33 per cent. there may be some doubt of the propriety of calling the other 67 per cent. a "waste." It is a waste only in the sense that the tailrace flow of a water power is a waste. In the present state of our knowledge we see no way in which it can be saved. But there is this curious fact. The animal organism is evidently a sort of a heat engine in which energy is produced by the combustion of food with a greater efficiency than we are able to obtain and with *no* perceptible temperature difference.

The average efficiencies of actual plants are much less than those quoted and the 5 per cent. which our correspondent mentioned is a very reasonable estimate.

Installing Tubes in Boilers

By H. S. Jeffery

A few hints upon the proper way to remove defective tubes and install new tubes in boilers. Special attention is given to the tools used and the manner of handling them.

The manner of installing tubes in boilers does not differ materially with various types of boilers. The hole in the tube sheet should be drilled as true as possible and should never be punched, as a punched hole does not have the same diameter for its entire depth, and the surface is more or less irregular and rough. It is good practice to drill the hole a little small and then ream out to the desired size, after which the edges are chamfered, as shown in Fig. 1.

In removing tubes from a boiler the

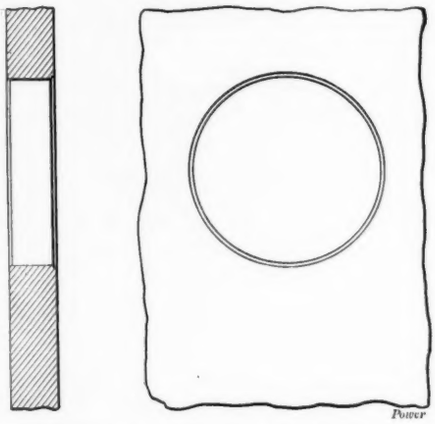


FIG. 1. EDGES OF HOLE CHAMFERED

head end of the tube is usually split, and the bead is cut from the firebox end of the tube. Then, by means of a maul and special tool, the tube is knocked out of the tube sheet and is removed from the boiler.

A ripper, shown in Fig. 2, is used in splitting the tube, after which a slit is cut into the tube, extending back beyond the tube sheet about one inch. This allows the tube to be closed in and removed through its own hole in the sheet. If scale adheres to the tubes to the extent that they cannot readily be removed in this manner, then they may be taken out through a convenient handhole. If this is not in a convenient location, the holes in the tube sheet may be enlarged and the tube extracted through it.

For this purpose it is necessary usually to enlarge the hole from ⅛ to ½ inch, depending upon the amount of scale adhering to the tubes. It should not, however, be enlarged more than necessary,

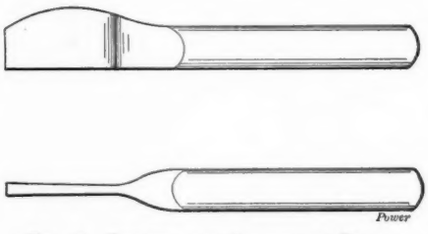


FIG. 2. RIPPER FOR SPLITTING TUBES

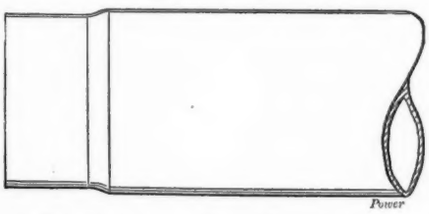


FIG. 3. END OF TUBE SWEDGED TO SMALLER DIAMETER

as it must be reduced to nearly normal size when the new tube is put in. The holes of the tube sheet in direct contact with the flames and hot gases are usually cut smaller than the diameter of the tubes, the latter being swedged to a smaller diameter; see Fig. 3. In some cases, especially with the locomotive type of boiler, a copper ferrule is placed between the tubes and the sheets. This usually applies only to the sheets directly in contact with the flames and hot gases, although some manufacturers use a copper ferrule in both tube sheets.

One method of fitting tubes to enlarged holes is by the use of heavy copper ferrules which reduce the size of the holes; see Fig. 4. This practice, however, has resulted in accidents, there being several cases of late where the beads became weakened at the firebox end and allowed the tube to become loose, with the result that the steam pressure, acting upon the tapered section and upon the bead, forced the tube out of the boiler.

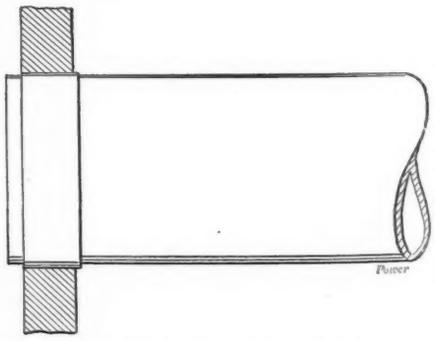


FIG. 4. HOLE REDUCED BY COPPER FERRULE

Another method is to place over the end of the tube a section of tubing about 6 inches long and of larger diameter, expanding to the tube sheet, as shown in Fig. 5. It is usual to have the short

section about ¼ inch greater in diameter than the tube. When it is necessary to enlarge the hole to a greater extent a steel bushing is used to reduce it to fit the tube; see Fig. 6. The bushing is expanded into the sheet before the tube

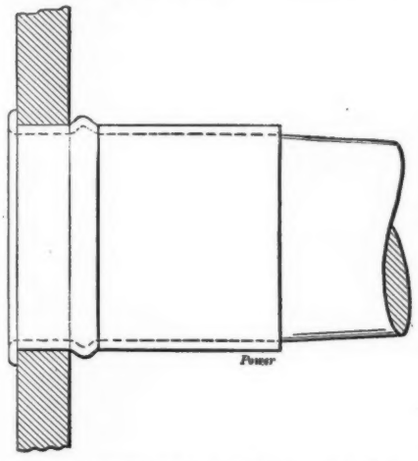


FIG. 5. SHORT PIECE OF TUBING USED TO REDUCE HOLE

is installed and the latter is expanded against the bushing. The use of a bushing for this purpose, although more expensive than the copper ferrule, is justified as the safety of employees and those near the boilers should be considered first, and the expense last.

The replacing of tubes in an old tube sheet must be done with utmost care. The sheets should be carefully inspected and all scale removed from the inside surface around the hole. The edges of the hole should be chamfered, leaving a good fillet to prevent the tube from being cut by sharp edges or burs. The holes are liable to be out of round, in which case they must be reamed. In some types of boilers there is a marked tendency for the firebox-tube sheets to expand more in a vertical direction than

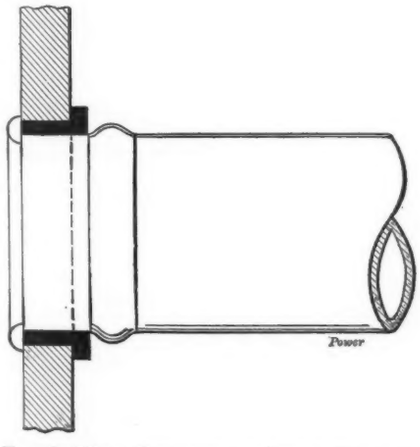


FIG. 6. HOLE REDUCED BY STEEL BUSHING

in a horizontal. This distorts the hole, the vertical diameter being slightly greater than the horizontal diameter. The holes at the center of the tube sheet usually suffer most from such distortion.

Before installing a set of tubes attention should be given to the sheets to see if they are straight, and, if not, they should be straightened as far as possible. This is accomplished by means of bars and bolts. When the sheet has been straightened, a number of tubes, depending upon the size of the boiler, are temporarily fastened to both tube sheets to permit the removal of the straightening bars, after which the balance of the tubes can be inserted and the operation completed.

It is general practice, with tubes which are beaded at one end and the other end expanded only, to cut them the desired length before inserting into the tube sheets. Sometimes there is more or less variation in the lengths of the tubes, in which case the tube sheet is divided into sections, the tubes of each section being cut the same length. They are then marked for their respective sections, and when installed all will project from the sheet about the same distance. If the tubes are to be beaded at both ends, then the measurements should be taken with more care, and the variation between the sections should not exceed 1/16 inch. Some boiler manufacturers design their boilers so as to use a special length of tube. These tubes are usually about

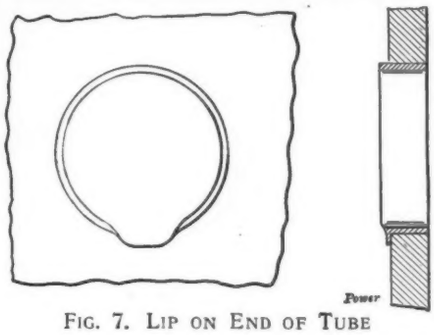


FIG. 7. LIP ON END OF TUBE

the right length and those that project too far beyond the sheets are cut off at the desired point by a special machine, although frequently a flat chisel and hammer are used. Tubes expanded into the sheet and not beaded should not extend beyond the sheet over 3/16 inch; those which extend too far beyond the sheets not only prevent proper expansion, but also permit the surplus part of the tube, which is not cooled by the water, to be burned or wasted away.

Tubes are expanded into the sheets by means of a roller, or sectional expander called a prosser. Some boilermakers use both the roller and the prosser in order to make a neat fit. When the tube is inserted into the hole it should project beyond the sheets from 3/16 to ¼ inch, which amount is allowed for the bead. The tube is held in place temporarily by lipping the tube with a hammer, as indicated in Fig. 7. The lip will hold the tube in position, while it is being expanded. If the tube is expanded by the use of the prosser only, a very common practice, the latter should be turned about four times. This forces the tube out against the sheet, which would not be the case if the prosser were not shifted.

The use of a heavy maul should be discouraged for driving the mandrel. A four-pound maul is sufficient and the blows struck upon the mandrel should not be

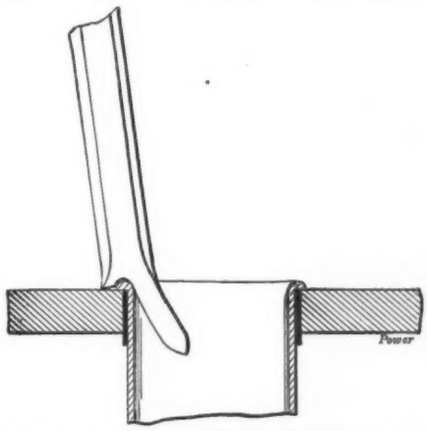


FIG. 8. BEADING TOOL WITH SHARP HEEL

heavy enough to cause the tube sheet to warp or spring. The tubes ought to be worked to the sheet and if this is done properly the sheet will not be distorted. A large tapering pin should never be used to enlarge the tube. The copper ferrules are annealed before being put into place and must be a neat fit. If too small for the hole they may be stretched and reannealed. In expanding tubes with the roller expander the mandrel should be forced in only a short distance at a time; otherwise, lumps will form and make the rolling unsatisfactory.

In working leaky tubes expand them very lightly when using the prosser, turning it about three times, and use an ordinary hammer. In expanding a leaky tube it is well to remember that heavy pounding is not required to tighten the tube in the sheet, as the tube has already the full contour of the expander. Beading the tube is very important. A beading tool constructed with a sharp heel is very liable to result in the sheet being cut

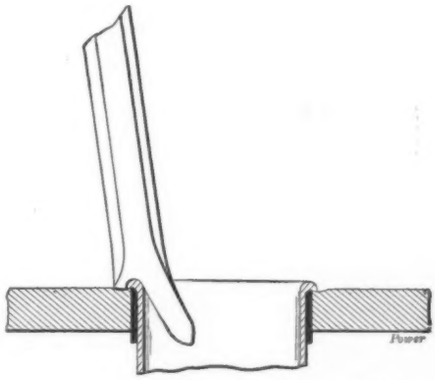


FIG. 9. BEADING TOOL WITH SQUARE HEEL

when the bead is calked. In Fig. 8 is shown a beading tool having a sharp heel, also the manner in which it cuts the sheet. In Fig. 9 is shown a beading tool with a square heel which prevents a groove from being cut into the sheet.

Boston Elevated Receiver Explosion

Some additional information on the receiver explosion which occurred in the Boston Elevated, Harvard Square plant. Receiver was 52 inches in diameter and was equipped with safety valve set for 50 pounds pressure.

In the October 11 number a short description was given of the receiver explosion which occurred on the morning of September 16, at the Havard Square power house of the Boston Elevated Railway, located at Boylston street, Cambridge, Mass. Further information is now available. The receiver connected the high- and low-pressure cylinders of a 4000-horsepower vertical compound engine which was direct connected to a 2700-kilowatt railway generator. The engine, as it looked previous to the accident, is shown in Fig. 1, and Fig. 2 shows the wreck.

The receiver which let go was made up of cast-iron sections, 1¼ inches thick and 52 inches in diameter. A 4-inch pop safety valve, set to blow at 50 pounds, had been placed on the receiver.

As the receiver burst, a great cloud of steam and water was carried over to the switchboard gallery which is shown in Fig. 3, and put about 15 lines out of service for a time.

A large piece of iron struck the governor of the engine which was carrying the load at the time of the accident and put this unit out of service for a great portion of the day until temporary repairs were made.

Fig. 5 shows the pieces of iron which went up through the roof, which is 40 feet above the engine, putting a 30-ton electric crane out of commission and tearing a great hole through the 6-inch concrete, strengthened by expansion metal. A large ventilator was smashed down and several small pieces were found several hundred yards away.

Fig. 4, a view of the end of the station taken from the Charles river road, shows how the windows were broken; it will cost several hundred dollars to repair the building. It will be an expensive job to repair the engine and generator, and several weeks must elapse before the unit will be ready for commission.

At the time of the accident there were seven oilers and engineers on watch. After the steam and asbestos cleared away, they went to work to see how many were lost, and found Ernest Lyons directly under the wreckage, where he had stood at the throttle on the high-pressure side. He was found to have several cuts and bruises about the body and one leg broken; although he is expected to recover, it will be six months or a year before he will be able to resume his duties as an engineer.

At this writing the exact cause of the accident is not known. An investigation by the company is still pending and some information may perhaps be given out at a later date.

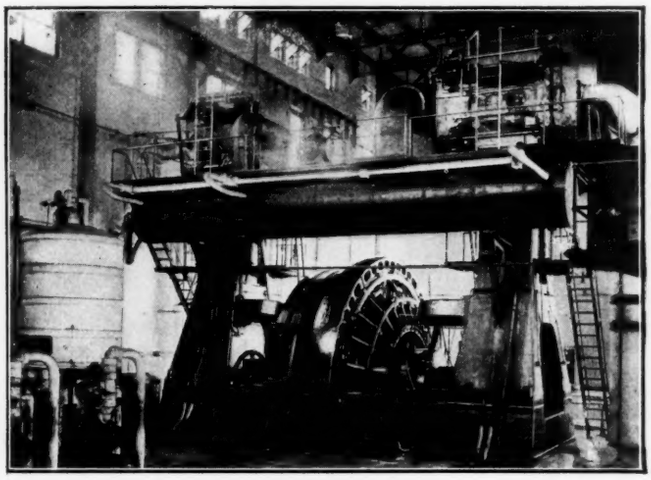


FIG. 1. BEFORE THE EXPLOSION

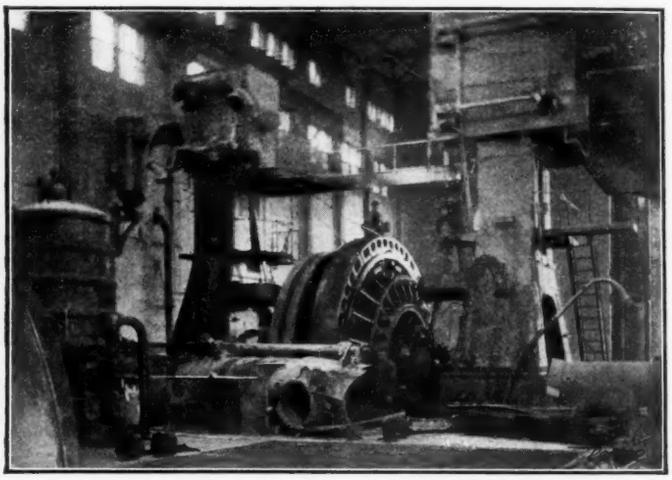


FIG. 2. THE WRECK

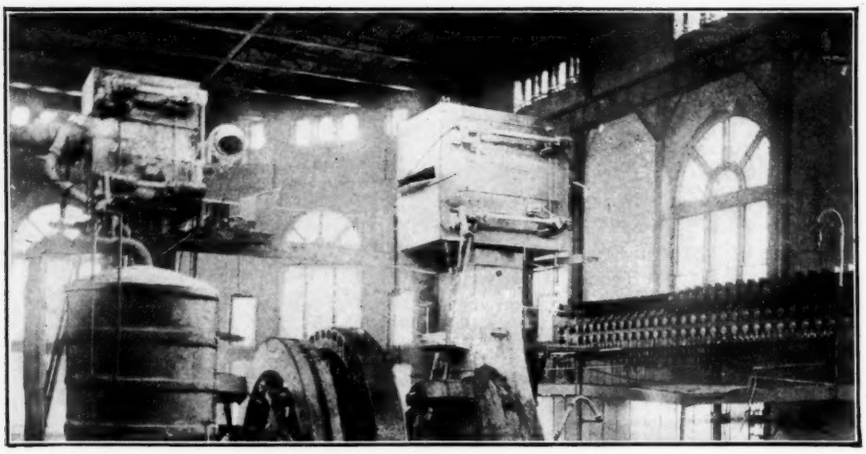


FIG. 3. VIEW OF DAMAGED UNIT AND SWITCHBOARD

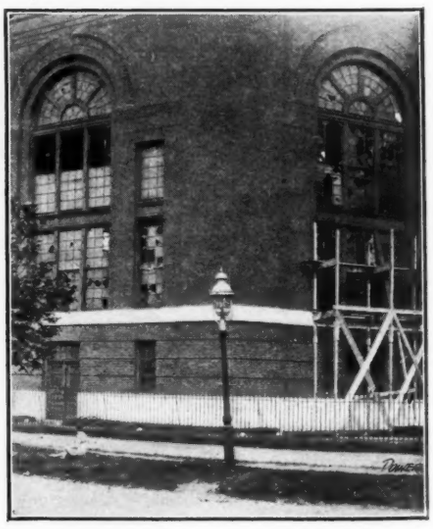


FIG. 4. DAMAGE TO WINDOWS

The Marine Engineer and His Work

By Thomas H. Heath

The marine engineer is handicapped by lack of space and adverse operating conditions. Breakdown usually occurs in rough weather. Conditions are being improved by the use of simplified machinery.

Among operating engineers, probably the marine engineer has to meet trouble under the greatest disadvantage. It is not with a fair breeze and smooth sea that he is most liable to "go up against it," but rather under the stress and strain of a heavy sea, when there is the greatest need for every wheel and cog to do its part, that the mishap or breakdown occurs. It is at this time when cool courage and experience count; when to meet the situation right may mean not only saving of time and damage to ship and cargo, but the lives of those on board as well.

This work has to be done generally under the most adverse conditions, in a rolling ship and with the limited space and means found aboard a vessel. It is bad enough to have things go wrong with good old mother earth beneath one's feet, but how much worse it is to have to do things in a tumbling ship that is wallowing around in the trough of the sea. It is hard enough to stand, much less make repairs.

FIG. 5. HOLES IN ROOF AND UPSET VENTILATOR—SEE PAGE 1828

Our wise old "Uncle Samuel," in his "Marine Regulations," says that no one can become a marine engineer until he has served his three years as oiler or fireman on the water. Then, if the would-be engineer makes good in an examination he gets his first "ticket," probably as a third or fourth assistant. After this it means another three or four years of marine engine-room service before he is allowed the coveted unlimited chief's papers. The man that has shown the ability and tenacity of purpose to go through this course of training is the man that is generally ready for the emergency.

As in a similar sized power plant ashore, the chief engineer of ocean-going steamers takes no part in the active operation of the machinery while things are going right. He exercises a general supervision, keeps in touch with things below and devotes some of his time to daily reports.

While the vessel is loading or discharging cargo in port, the engine-room crew is busy getting things in shape again for the next cruise. Boilers are washed and looked after, bearings taken up, pumps looked into, repairs made where necessary and everything made ready for the next voyage, which may mean days and weeks without a slow down.

Coal has to be bunkered, supplies got aboard and fifty other things not forgotten; for, after once at sea, it is not a matter of telephoning uptown for something that is required. The tanks are filled with fresh water for human use and boiler feed. The evaporators are used only when a shortage occurs before reaching port.

Ocean-going vessels generally carry well stocked store rooms. Besides repair supplies and tools that would meet most requirements or needs, duplicates of many of the parts of the engines and auxiliaries most likely to give out are carried. Modern marine engines are multiple expansion, from compound to quadruple. When possible, the different parts of the engine are made interchangeable; for instance, crank brasses, eccentrics, crosshead brasses and many others. One or two spares of each of these with their bolts and accessories are carried to replace any one that may give out.

The crank shafts on most marine engines nowadays are made up in sections —a section for a cylinder, each section interchangeable so that in case of a broken crank shaft the part fractured may be taken out and the spare section substituted. For example, the triple-expansion crank shaft is made in three sections, each of which is exactly like the others; an extra section carried in reserve can be used to replace any one of the three in case of failure.

One of the most prolific causes of serious breakdown in a rough sea is the racing caused by the propeller being partially cleared of the water due to the plunging of the vessel. This, of course, is hard on the engines and it is at such times that things are liable to let go. Various governors have been devised in attempts to stop this racing but with engines that expand steam in three or four cylinders no scheme yet devised will come up to the old-fashioned way of handling the throttle.

One of the things that the marine engineer is constantly on the watch to prevent is sea water getting into the boilers. A little leak through some of the sea connections on the feed-pump lines or cooling water getting through into the steam space of the condenser may make trouble. Salt raises the mischief with the tubes and plates as well as the pipes and fittings. It also causes priming. A salinometer is a part of the equipment of all marine-engine rooms.

Bilge water is also one of the cares of the engineering department. Besides the regular bilge pumps, the circulating-pump suction line is arranged to take water from the bilge in case of an emergency.

Besides the main engines and boilers with their auxiliaries, there are the electrical plant, the refrigerating plant, the steering engine, the wireless apparatus and many other pieces of equipment. Most of these are huddled into about half the space or less that a similar equipment of equal capacity would occupy ashore.

Changes are taking place with the marine engineer as well as with his brother on land. The complicated reciprocating engines are giving way to the simpler and safer turbine. The safety of the ship does not now depend on a single propeller, for twin screws and even triple screws are replacing the single. Future requirements on water seem to point toward more power, greater speed and increased tonnage. Whatever the requirements may be, given a reasonable show, the marine engineer will be on hand to "deliver the goods."

Safety Stops for Steam Engines

By W. H. Wakeman

Types of safety stop consisting of special designs of valve, some of which are operated by steam and others by electricity.

A number of safety stops are made in the form of special valves connected to the steam pipe above the throttle valve. Several of these stops are herewith described.

In Fig. 1 is shown a butterfly valve located just above the engine throttle valve. The rod shown at the right is attached to a special governor run by a belt from the crank shaft. When the regular governor fails to control the engine speed, the rod is detached from the valve stem *A* and the weight *B* closes the valve.

Stops which close the throttle valve, or a special valve in the steam pipe are especially useful in connection with high-speed engines that are not fitted with disengaging valve gears. They are also applicable to engines that operate at lower speeds, but do not permit the application of a device that operates on the steam valves. However, they can be used on a Corliss engine, as illustrated in Fig. 2.

This device resembles the steam valve of a Corliss engine except that it is made

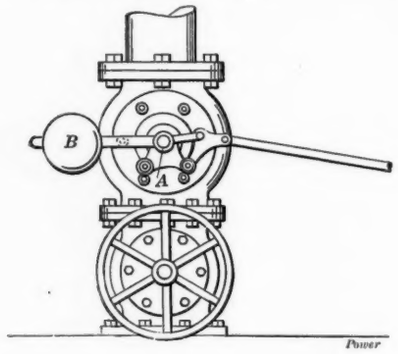


FIG. 1.

shorter and the port is accordingly wider. If the speed of the engine is increased above a certain point a knock-off cam trips the latch and the weight attached to the valve-stem crank closes the valve. If the governor belt breaks, the same result is secured, for, although the movement is downward instead of upward, another part of the knock-off cam is rolled into contact with the latch, which is tripped. and the valve is closed. The governor must be blocked before the throttle valve is closed when the engine is to be shut down.

The difference between a stop that operates for both increase and decrease of governor speed, and one that acts for increase only, is that the latter stops the engine if the valve gear is so adjusted that the steam valves admit enough steam to run the engine at a dangerous rate at the shortest possible point of cutoff, when the load is very light. This condition can be produced by setting the collar on the governor spindle so low that the center weight cannot go as high as the engine builder intended. It is an easy matter to make this mistake, and it has been made in many cases where the engineer does not suspect it, therefore every engine ought to be tested for this defect. If the governor belt breaks the engine will first run faster for a few seconds and then stop.

In the case of a stop that operates for increase of speed only, as long as the governor belt is in good order and stays on the pulleys, there is no danger of a flywheel wreck from excessive speed, even if the steam valves remain open after they ought to be closed, because steam will be shut off by the independent valve, but if this belt fails and the engine begins to race, there is nothing to stop it.

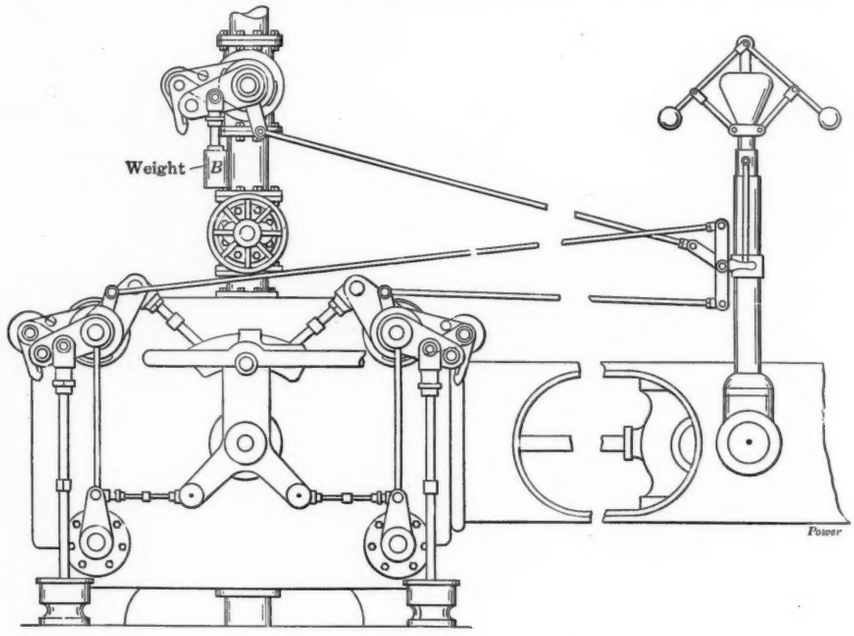


FIG. 2.

Fig. 3 illustrates an independent auto-

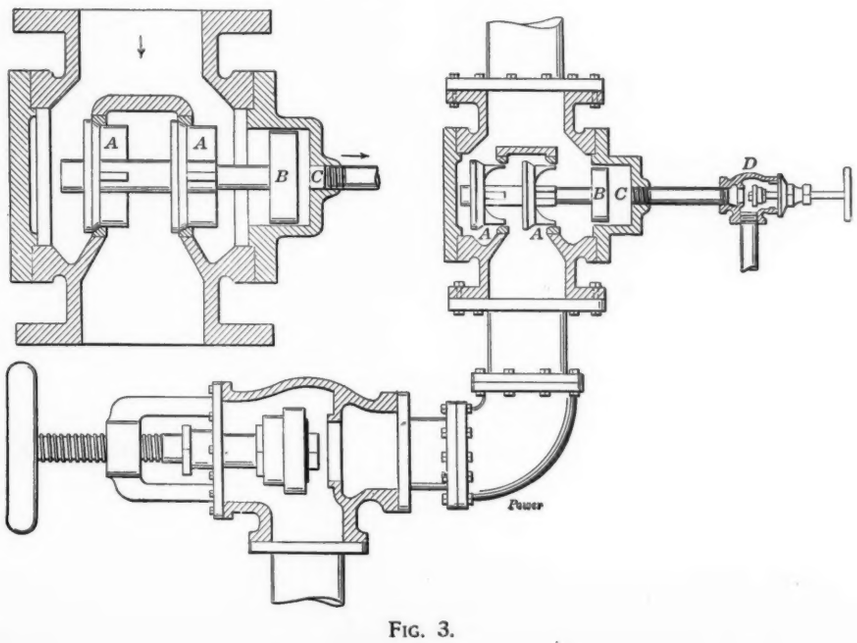


FIG. 3.

matic stop valve located above the throttle valve of an engine. Both are wide open allowing steam to pass freely to the engine. The view at the left of Fig. 3 shows the stop valve shut. Fig. 4 is an external

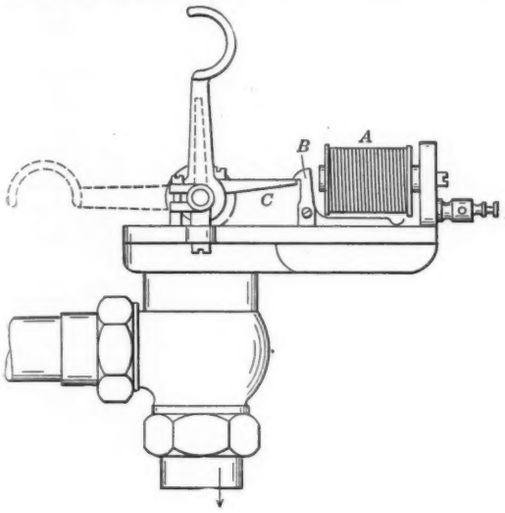


FIG. 4.

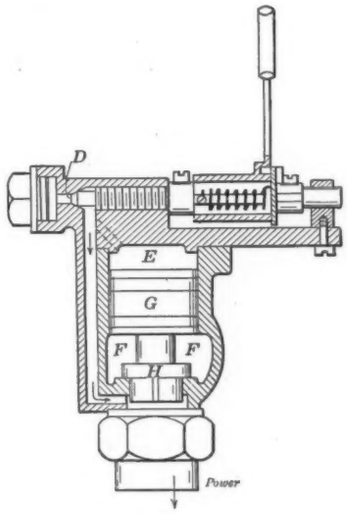


FIG. 5.

view of the device which closed it and Fig. 5 is a sectional view of it. In Fig. 3 the stem and poppets *A* are in equilibrium, and, so far as they are concerned require but little external force to move them. They are held in the position shown by the difference in total pressure acting on opposite sides of the piston *B* as it allows steam to pass it until full pressure

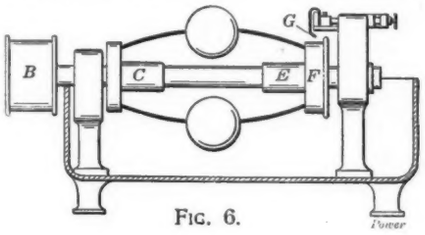


FIG. 6.

is secured in the chamber *C*, also in and through the angle valve *D* which is left open for this purpose. Valve *D* is used to shut off pressure when repairs or adjustments are required. The pipe from the valve *D* leads to the device shown in Fig. 4.

Pressure acting on *B*, Fig. 3, holds the valve open because the full area on the outer face is exposed to pressure, while the rod occupies a portion of the inner face, thus reducing the effective area. For illustration, suppose that the piston *B* is 4 inches in diameter, and the rod 1 inch. The steam pressure is 100 pounds on both faces of *B*. The effective area is 12.56 square inches on the outer face, giving a total force of 1256 pounds. On the inner face it is 11.78 square inches, and the total pressure is 1178 pounds, therefore, the difference is 78 pounds which operates to open the valve and hold it open.

The figure shown at the left of Fig. 3 illustrates the stop valve after steam is exhausted through the outlet *C*, thus removing all pressure from the outer face of *B* and, therefore, the full force of 1178 pounds operates to close the poppets *A A*, and promptly shut off the steam.

Fig. 4 is an automatic angle valve which is closed under normal conditions, but when an electric current is sent through the armature *A* it attracts the pawl *B* and releases the latch *C*, which is moved by a coiled spring through one-quarter revolution, as represented by the dotted lines.

Fig. 5 is a sectional view of the same device taken at right angles to the preceding illustration, consequently the inlet does not appear. When the pawl releases the latch it opens the small valve *D*, allowing steam to escape from *E* through a passage shown by the dotted lines into the vertical space below *D* and thence into the exhaust pipe, as shown by the arrows. Full pressure acting at *F F* raises the piston *G*, also the poppet *H* and exhausts all steam from the space *C*, Fig. 3, and closes the automatic stop valve.

Current from a battery is sent through *A*, Fig. 4, when the circuit is closed by the speed-limit governor shown in Fig. 6. The pulley *B* is driven by a belt from the crank shaft. The part *C* cannot move endwise on the shaft, but *E*, at the opposite end, is free to slide. The flyballs are in position to represent normal condi-

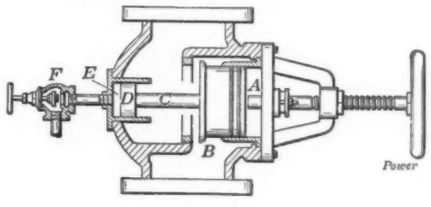


FIG. 7.

tions of speed and service, but a slight increase of engine speed throws them out further until the spring holder *F* comes in contact with *G*, completing the circuit and closing the automatic stop valve as already described.

A hand-operated throttle valve combined with an automatic stop valve which does not utilize electricity in its operation is shown in Fig. 7. When the wheel is turned from right to left hand, the

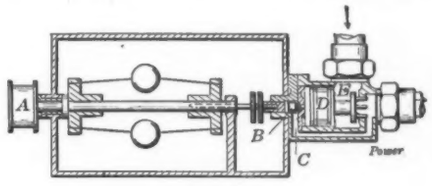


FIG. 8.

valve is opened, although the stem *A* and disk *B* are not connected mechanically. When this valve is closed by turning the wheel from left to right, steam pressure acts only on the left-hand side of the disk and as the valve stem is withdrawn by turning the wheel the disk follows it. The stem *C* and piston *D* are connected to the disk, but steam at full pressure fills the space *E*, therefore, under normal conditions piston *D* is in equilibrium and has no effect on the valve action. When steam is exhausted from *E*, however, pressure acts on the other side of *D*, closing the valve. The angle valve *F* is for the purpose of shutting off the closing attachment,

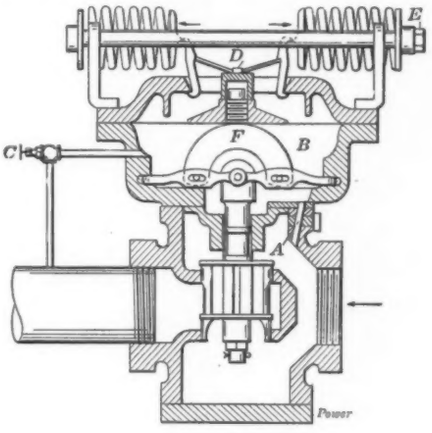


FIG. 9.

but it should always be open when the engine is running.

Fig. 8 shows a device for closing the valve by steam pressure. The pulley *A* is run by a belt from the crank shaft. The flyballs are mounted on flat springs and are shown in normal running condition. A small valve *B* closes the exhaust passage *C* and the steam pressure is equal on both sides of the piston *D*. The inlet receives steam from *F*, Fig. 7, but it cannot pass out when the valve disk *E*, Fig. 8, is closed. If the crank-shaft speed is increased the governor balls are spread by centrifugal force, causing *B* to open and let steam escape to *C*. As pressure is removed from one side of *F* it is forced toward the left, which relieves the pressure in the chamber *E*, Fig. 7, and the valve is closed. The automatic stop valve is usually located over a steam chest on a

Corliss or other long-stroke engine, while that shown in Fig. 8 is near the crank shaft, but this is not essential, as it is only necessary to reduce pressure in the exhaust pipe, and that can be done from a distant point. By using a tee in this pipe and running a branch line to a convenient point with a globe valve in it, the stop valve may be tested at pleasure. If the automatic device is wrecked by an accident the engine can be shut down without going to the throttle-valve wheel.

Fig. 9 illustrates a self-contained automatic stop valve that will shut off steam whenever the pressure is reduced on the outlet side. Steam enters at the right, as indicated by the arrow, and as the valve is closed, the only outlet is the small passage *A*, which allows steam to pass into the chamber *B* until full pressure is secured at this point, because the angle valve *C* is closed. This valve and the connecting pipes must always be larger than the passage *A*. Pressure acts on the diaphragm above *B* and raises *D* against the two spiral springs, which are thus forced apart as indicated by the arrows. The tension of these springs is regulated by the nut *E*. This tension determines the point at which pressure shall be shut off automatically. When nearly full pressure is realized in chamber *B*, the main valve is drawn upward by the diaphragm and connection *F*, allowing steam to pass through and equalize the pressure, after which *C* is opened. Assuming that this pipe supplies steam to an engine, and that on account of failure of the governing mechanism, the engine begins to race, taking steam so rapidly that pressure is reduced in the supply pipe and also in chamber *B*. The springs are then stronger than the steam pressure and the main steam valve is closed.

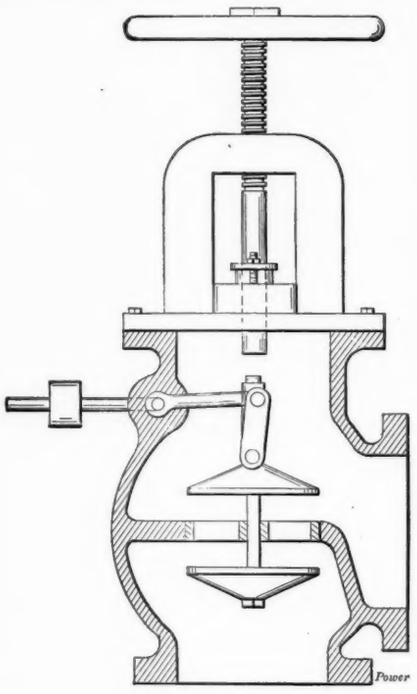


FIG. 10.

If the engine is heavily loaded and pressure is reduced in the supply pipe, the main steam valve will shut down the engine even when there is no danger. To overcome this objection the springs must be set to operate at a lower pressure. Care must be taken to avoid excessive difference in this respect, or else the valve will not operate when the engine "runs away." Suppose that the usual boiler pressure is 100 pounds and this valve is set to operate at 80. If the boiler pressure is allowed to fall to 80 the engine will be shut down. While this is an objection from the fireman's standpoint, it may not be an unqualified evil from the engineer's point of view, as it will be a great inducement to maintain a steady boiler pressure, thus securing good results in the use of steam. If the pressure falls below 80 at night or whenever the engine is shut down, the automatic valve will close, making it impossible to start until the boiler pressure is raised, or the tension on the springs is reduced.

Fig. 10 illustrates an automatic cutoff valve which does not depend on a reduction of pressure for its operation. The internal parts are balanced by a weight on the outside, and a dashpot prevents chattering when steam is taken rapidly and cut off quickly. Under normal conditions, this valve remains open and will deliver a reasonable quantity of steam, but if the engine "runs away" the extraordinary flow of steam caused by excessive speed, closes the valve and shuts off the supply of steam.

Darky Engineer Had a Hot Crank Pin

Somewhere in the "good book" it says, "Let there be light: and there was light." This quotation brings to mind a little experience one of the editors of POWER had some time ago when visiting a manufacturing town in the sunny State of North Carolina.

Desiring to observe usual formalities, the office of a small cotton mill was hunted up, but the door was locked and the management was evidently allowing things to take their own course, although it was long past the regular time for starting up after the lunch hour. Wishing to view the power plant and trusting that no unpardonable sin would be committed in doing so without a permit, the visitor passed in through the boiler room to the engine room, where he found the coal-black darky in charge studiously perusing his Bible. The darky, by the way, was a substitute for the regular engineer who happened to be sick.

Whether "Sambo" was reading the above quotation or not will never be known, but he was deeply absorbed in whatever he was reading, so much so in fact that he did not at first notice the arrival of a visitor or that the crank pin of the 200-horsepower Corliss engine was smoking. Upon his attention being called to it, the darky closed his book and grabbed an oil can, making the remark as he did so, "I done smell dat 'ar smoke, but I dunno whar it cum frum."

The visitor, not feeling in a position to advise slowing down the entire mill in order to loosen up the brasses, suggested that he get the oil cup to feeding, which he had neglected to do upon starting the engine at the end of the dinner hour, to copiously flood the pin and to hustle for instructions as to what had better be done. Frantic appeals were then sent to the residence of the mill manager, who came in on the run a short time afterward.

Sometimes good intentions are thrown to the winds and are not appreciated; it was so in this case. While the darky was hunting for the manager, the visitor was industriously squirting oil on the hot crank pin. Upon his arrival, the manager proceeded simultaneously to cuss the darky and to shut down the engine. Now engineers know that the babbitt in brasses and a hot crank pin, particularly when as hot as this one, have a strong affinity for each other, especially when the engine is stopped.

As the evident intent of the manager was to shut down the engine at once, the visitor timidly suggested that he keep the engine turning over slowly until he had his brasses loosened up a trifle and cooled down. The suggestion was not kindly received, for the manager, quickly turning, said: "Who the —— are you! What the —— do you want?" Then the visitor was emphatically informed that he, the manager, was a graduate from two or more universities, and that he had also made good with a large electric-manufacturing company. Feeling properly squelched, the visitor humbly withdrew, wondering as to the fate of the darky.

The next day while visiting a neighboring machine shop, one of the machinists stated that he had a Sunday job at the ———cotton mill, which would indicate that the manager had again "made good."

Tests on a 12x30 Corliss Engine

By J. A. Polson

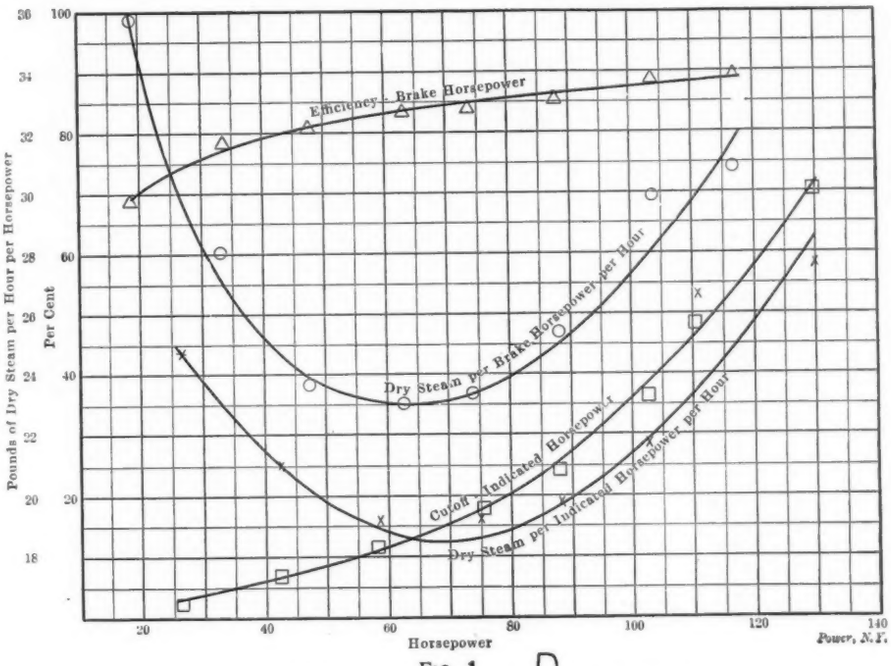


FIG. 1

The engine on which these tests were run is a standard 12x30 Corliss engine built by the Nordberg Manufacturing Company, of Milwaukee, Wis. It is of the long-range cutoff type and has three eccentrics, two of which operate the steam and exhaust wristplates and the third operates the cutoff mechanism in connection with the governor.

The engine is a part of the permanently installed equipment of the engineering laboratory of the Michigan State Agricultural College at East Lansing, and is used for testing purposes and for instruction for engineering students.

The power developed by the engine is absorbed by a friction brake of the prony type, the pressure being determined by weighing on a platform scale. The brake wheel is 6 feet in diameter with a 24-inch face, and provided with internal flanges for water cooling.

The data from which these results have been worked up by the writer were taken some time ago by the students in the laboratory.

In running these tests the conditions were kept as nearly uniform as possible for an average period of 50 minutes, with 10-minute readings. Indicator diagrams were taken simultaneously from each end of the cylinder, using Crosby indicators and reducing motion. The revolutions were taken by a continuous revolution counter. The condensed steam was weighed on platform scales, two tanks and scales being used to facilitate weighing. The results have been worked up in the usual way and averaged, and are given in the table on following page.

The quality of the steam was nearly constant at 96.8 per cent. The low quality of the steam is accounted for by the fact that the engine is about 200 feet from the power house. The quality of the steam was determined by a throttling calorimeter at the engine throttle. The steam pressure given in column 2 of the table was also taken at the throttle valve.

The series of tests given cover pretty well the range of the engine under the given pressure, as can be seen by a glance at the sample diagrams given in Fig. 2. Those marked *a*, *d* and *h* are average diagrams taken under the tests marked by the same letters in the table.

In Fig. 1 the results given in the table are plotted on a common base of horsepower and plainly show the behavior of the engine under increasing load.

The lowest steam consumption is 23 pounds per brake horsepower-hour and occurs when the engine is developing about 62 brake horsepower. The steam consumption is 19.2 pounds per indicated horsepower at this load. The diagrams

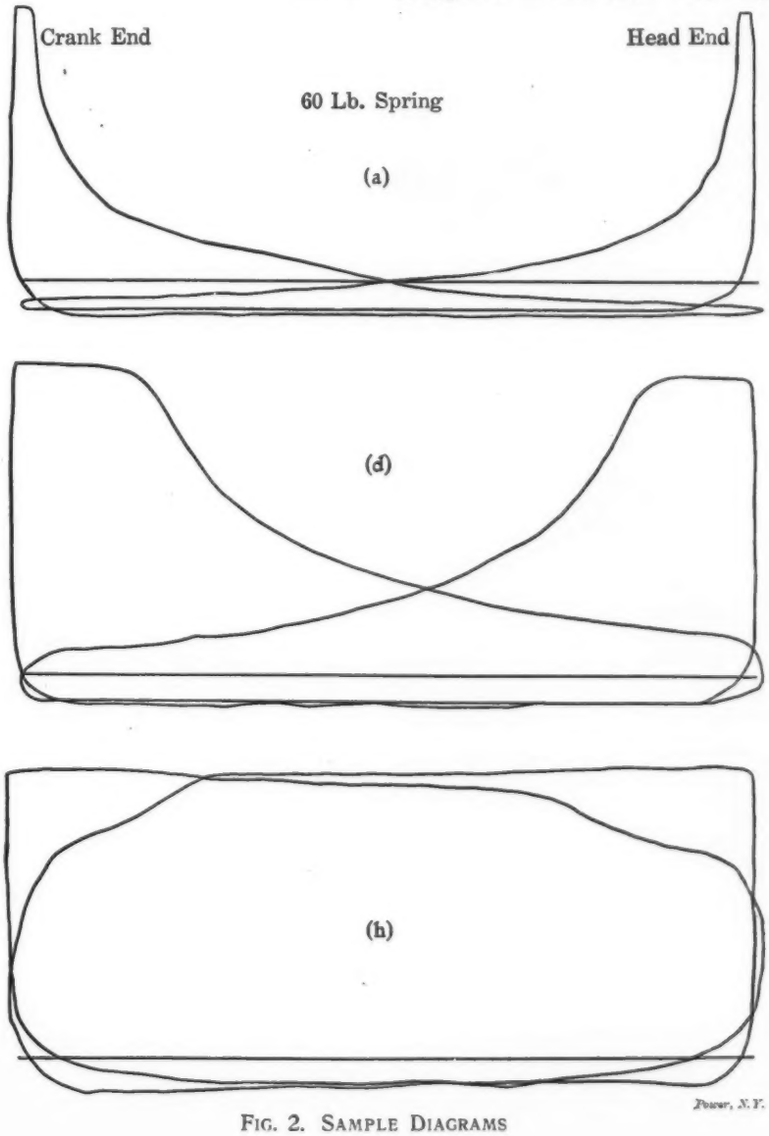


FIG. 2. SAMPLE DIAGRAMS

marked *d* in Fig. 2 are representative diagrams from this test.

As the long-range cutoff is a special feature of this engine, it is interesting to note how the cutoff increases with increasing load. This is the average cutoff for both ends and is shown by a single curve. At a load of 25 horsepower cutoff takes place at 3 per cent. of the stroke, at 80 horsepower cutoff has increased to 20 per cent. of the stroke and at 130 horsepower cutoff occurs at three-tenths of the stroke. The mechanical efficiency ranges from 69 to 89.9 per cent.

RESULTS OF TESTS.

No. of Test.	Av. Steam Press., Gage.	Av. Vacuum, Inches Mercury.	Rev. per Minute.	Horsepower.			Mechanical Efficiency, Per Cent.	Dry Steam Per Hour.		Average Cutoff, Per Cent.
				Brake.	Indicated.	Friction.		Brake Horsepower.	Indicat'd Horsepower.	
1	2	3	4	5	6	7	8	9	10	11
a	94.5	20	89.56	18.25	26.48	8.23	69.0	35.7	24.6	2.5
b	94.8	20	89.32	33.17	42.6	9.43	78.2	28.0	21.0	6.4
c	94.1	20	89.0	47.25	58.38	11.13	81.0	23.6	19.1	11.2
d	95.4	20	88.74	62.44	74.8	12.36	83.4	23.0	19.2	17.5
e	96.0	20	87.88	73.75	87.1	13.35	84.6	23.3	19.7	24.1
f	96.0	20	86.64	87.78	102.6	15.82	85.5	25.4	21.7	36.3
g	93.5	18	85.4	103.1	115.6	12.5	89.2	29.9	26.6	48.0
h	91.5	18	84.14	116.4	129.6	13.2	89.8	30.8	27.7	70.5

Locomotive Boiler Explosion

By F. Krebe

Low water given as cause of explosion which killed the engineer and fireman and, with the exception of the trucks, practically destroyed the engine.

The accompanying photographs show the remains of a locomotive which exploded on October 1, about three miles west of Tennessee Pass, on the Denver & Rio Grande railroad. The photographs were taken in the yards at Salida, Colo., immediately after the wreck was brought in. Three locomotives, two pulling and one pushing, were taking passenger train No. 2 up a steep mountain grade, when the front engine, at the head of the train, exploded. The boiler proper, as shown in Fig. 1, was blown 200 feet forward, and about 80 feet to the side of the track. The firebox sheets, or lining, were blown 600 feet to the side, except the back head, in which the fire doors are placed. This was blown forward 600 yards. It is a mystery to all concerned how the back head could have been blown forward, unless the boiler turned around before the explosion occurred. The engine trucks remained on the track, and it required only about an hour's work to get them in shape to be pushed on a siding close by. Fig. 2 shows the trucks just as they stood after the explosion, with the exception that the side rods were taken off to permit bringing the trucks into the yards. Fig. 3 shows the firebox sheets as they were picked up and placed in a gondola car.

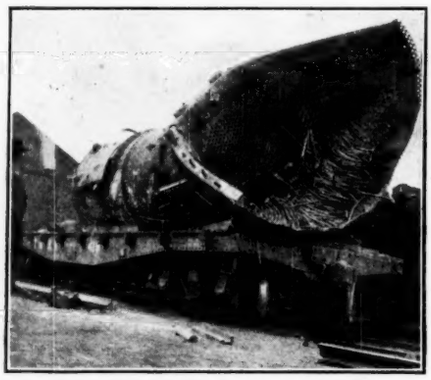


FIG. 1. THE BOILER PROPER AFTER THE EXPLOSION

The Government inspection following the explosion resulted in a verdict of low water as the direct cause of the explosion, and this seems to be the consensus of opinion of others who examined the plates, and who were competent to know.

The body of the engineer was found 250 feet up on the side of the mountain, with both legs completely gone; these were found close to the rear end of the train. The fireman's body was blown across the river 500 feet from the train, and was frightfully mangled.

The second engine escaped with but little damage. The head light was pushed off, and the engine-cab windows were broken. Neither fireman nor engineer of the second engine were hurt, and the two engines proceeded with the train.

The engine which exploded was only two years old, and had just been put in good repair. The life of an engine on these mountain roads is about five years, at the end of which time they must be practically rebuilt.

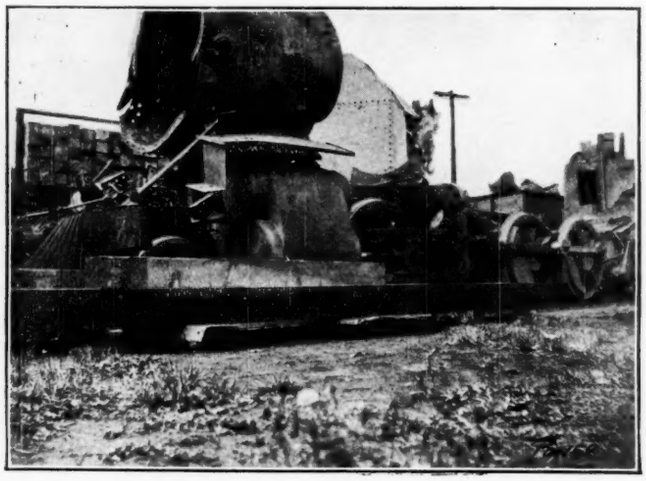


FIG .2. TRUCKS AND FRONT COURSE OF BOILER

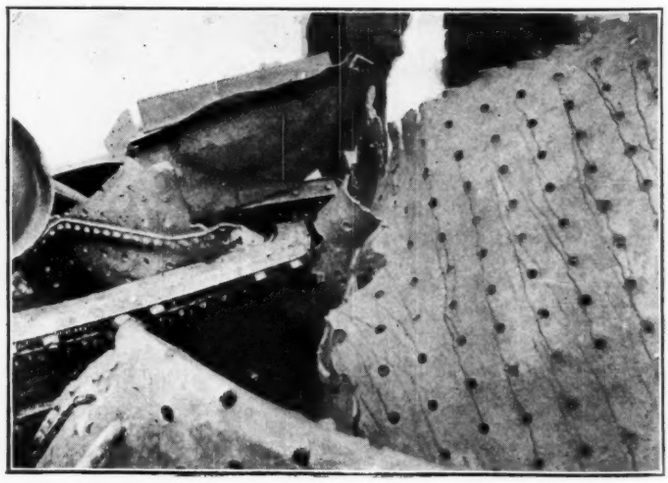


FIG. 3. FIREBOX SHEETS LOADED ONTO A GONDOLA

Notes on Causes of Boiler Failure

By A. A. Adler

Among the causes due to operating conditions are overpressure, overheating, scale, lamination of the metal and, possibly, the spheroidal state of water. Structural causes include imperfect methods of bending the sheets and driving the rivets and the weakness characteristic of the lap joint.

Some boilers explode clearly from overpressure, due to erroneous gage readings and defective or erroneous setting of the safety valves. Overpressure may also be wilful. There is no remedy for this state of affairs further than the elimination of the cause.

Overheating of the plates and tubes is another cause. Such a condition is evinced by the bulging of the steel due to the internal pressure, and the plastic condition of the steel at the high temperature. Scale, lamination in the steel, low water and possibly the spheroidal state of water may be the causes. The spheroidal state of the water may be defined as that state where the water is separated from the plate by a film of steam through which the transmission of heat is somewhat retarded, sufficiently so to cause a rise in temperature of the plate. This latter condition is probably due to forcing the water to evaporate faster than the circulation can bring new water surfaces to the plate. The remedy for the various conditions is evident.

There are cases on record where the boiler exploded on the opening of a valve after the boiler had been lying idle for some time. Aside from the structural defects, this is the most dangerous condition that there is to contend with.

It is a known fact, that the temperature of water can be raised several degrees above its boiling point, when it is in an absolutely quiet condition and holds no entrained air in it. The temperature may likewise be lowered several degrees below the freezing point. Suppose a boiler to be full of water in a superheated condition due to its quiescent state. If this state be disturbed by drawing off some steam, the temperature of the water will immediately drop a certain amount and the surplus heat will convert some water into steam, and thereby raise the pressure suddenly. The temperature of the water will then be the same as that of saturated steam at the new pressure.

What the extent of this pressure rise is I am not prepared to say very definitely. As the condition exists, it seems as though it is not a negligible quantity. A case will be taken, however, and the extent of the superheating of the water necessary for a certain rise in pressure will be estimated.

Assume a boiler 5 feet in diameter and 16 feet long. The weight of water contained in this boiler when two-thirds full, is

$$5 \times 5 \times 0.7854 \times 16 \times 62.4 \times \tfrac{2}{3} = 13{,}067$$

pounds of water, neglecting the space occupied by the tubes. The steam space for this boiler being ⅓ its capacity is,

$$5 \times 5 \times 0.7854 \times 16 \times \tfrac{1}{3} = 104$$

cubic feet.

HEAT CONTENT AT 100 POUNDS GAGE PRESSURE ABOVE 32 DEGREES FAHRENHEIT

(Total heat of water) = 13,067 × 305.8 =	3,996,000 B.t.u.
(Total heat of steam) = 104 × 0.257 × 1188.8 =	31,774 B.t.u.
Total heat of boiler.....	4,027,774 B.t.u

HEAT CONTENT AT 150 POUNDS GAGE PRESSURE ABOVE 32 DEGREES FAHRENHEIT

(Total heat of water) = 13,067 × 333.9 =	4,363,000 B.t.u.
(Total heat of steam) = 104 × 0.3626 × 1195 =	45,063 B.t.u.
Total heat of boiler....	4,408,063 B.t.u.

The difference in boiler heat content is,

$$4{,}408{,}063 - 4{,}027{,}774 = 380{,}289$$

B.t.u., and the superheat necessary to produce this result is,

$$380{,}289 \div 13{,}067 = 29$$

degrees approximately.

The question now arises, is such a rise in temperature probable? Water may be heated as high as 290 degrees Fahrenheit at atmospheric pressure, which is 78 degrees above its boiling point.* It is, of course, questionable whether this same rise occurs at the higher pressures, but as I have not gone to the extreme in the example, the reader may admit its probability.

To show the effect of this sudden pressure rise, assume the boiler pressure to be as before, 100 pounds. Then, assume the pressure to rise suddenly to 150 pounds. This sudden increase of 50 pounds produces a momentary strain in the shell equivalent to a steady pressure of 100 pounds, and the resulting strain in the boiler shell is that due to 200 pounds. Should the boiler be near its limit of strength due to the 100-pound pressure; this suddenly applied increase of pressure might be sufficient to cause rupture.

Some people seem to think that water-hammer caused by the sudden opening of a valve is a cause of explosion, but I do not give much credit to this, as the steam that is drawn off may be less in amount than the fluctuation caused by an engine under a variable load.

*Ennis—"Applied Thermodynamics."

POSSIBLE STRUCTURAL CAUSES OF FAILURE

Tubular boiler plates are made by putting a flat plate in a bending roll and rolling it until it assumes a circular shape. This is done with the material cold, and hence strains are set up in the plate which exceed its elastic limit, otherwise the plate would immediately return to its original shape. In the ordinary process the bending roll is unable to bend the end of the plate with the result that this portion of the plate does not have a circular shape but remains straight. As this portion forms the joint and, as will be shown later, the joint is a very important place, special precautions should be taken to have it conform to a true circular shape. Possibly cold rolling does not injure the boiler very much, but it must, nevertheless, be treated as an un-

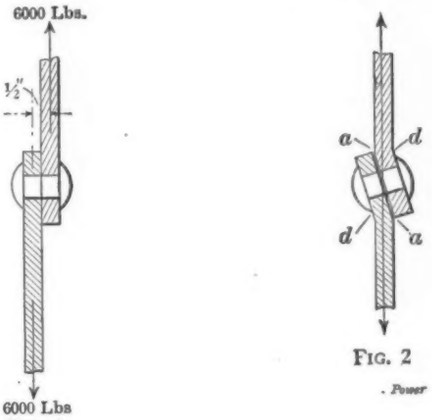


FIG. 1 FIG. 2

LAP-RIVETED JOINT AND BENDING EFFECT PRODUCED BY STRESS

certain element in the design. Cold rolling increases the tensile strength of the plate at the expense of its ductility.

The cooling of the rivets sets up unknown stresses, drifting, if permitted, has its attending dangers, and overpressure on the rivet produces strains in the metal at the sides of the hole. Even the method of supporting the boiler and the introduction of diagonal bracing, set up strains that are usually lost sight of in the design. In fact, all of the shop operations tend to impair the value of the finished product.

When a piece of lap-riveted joint is put in a testing machine the position of the plates with respect to each other will change from that shown in Fig. 1 to that in Fig. 2 on failure of the test specimen. The line of stress tends to become straight and when the forces are not in a straight line, there is a bending tendency, which increases the strain in the joint.

For the purpose of computing the amount of this strain assume a plate of

60,000 pounds ultimate tensile strength. Using a factor of safety of 5 and neglecting the so called efficiency of the joint, the allowable stress on the plate will be 12,000 pounds per square inch. If a plate ½ inch thick is used and a strip 1 inch wide is considered, working stress will be 6000 pounds on the strip, as its area is ½ square inch. When one piece of plate is riveted to another, the distance between the forces acting on the center of gravity of the plates is ½ inch and the bending moment for this condition of loading is,

½ load × length of lever arm,

or

$$\tfrac{1}{2} \times 6000 \times \tfrac{1}{2} = 1500$$

inch-pounds. This bending tendency must be withstood by the internal resistance of the plates. Since,

$$\text{Fiber stress} = \frac{\text{Bending moment}}{\text{Section modulus}}$$

and the section modulus for a strip 1 inch wide and ½ inch thick is $\frac{1}{6}\ b\ h^2$, where $b = 1$ inch and $h = \frac{1}{2}$ inch, or it is

$$\tfrac{1}{6} \times 1 \times \tfrac{1}{2} \times \tfrac{1}{2} = 1/24.$$

That the joint bends in two places must also be taken into consideration. Hence, the resulting stress is half of that which would be caused by bending in one place and the section modulus as 1/12 instead of 1/24.

The bending stress in the plate is, therefore,

$$\frac{1500}{\frac{1}{12}} = 1500 \times 12 = 18{,}000$$

pounds at the outermost fibers. Since in a plate that is bent, there exists a tension on one side *a*, Fig. 2, and a compression on the other side *d*, and in addition there is an initial stress of 12,000 pounds to the square inch, the resulting total stress in the joint is

$$18{,}000 + 12{,}000 = 30{,}000$$

pounds tension at *a* and

$$18{,}000 - 12{,}000 = 6000$$

tension at *d*.

The plate is then up to the elastic limit, except for the reasons that will be noted. Had a thinner sheet been assumed, the stresses would not have run up quite so high; they are, nevertheless, very much greater than is sometimes supposed. The material when stressed up to its elastic limit does not indicate failure, but its reliability is impaired. The boiler may be somewhat out of round which circumstance also may cause the stress to become still higher.

The corrosive action of water seems to be much more effective at places where the stress is high, due probably to the increased porosity of the material when under stress. As the corrosion reduces the section of the metal, the stress per unit of area increases and a more vigorous corrosive action follows with the result that the dangerous grooving takes place which is so often seen in lap-riveted boilers.

The result of the foregoing analysis is sufficient cause to reject this type of joint for boiler uses at least.

The problem is somewhat complicated by the strengthening effect of the heads of the boiler. The strengthening effect is considerable for short drums, and gets less as the boiler gets longer. Again, as the plates bend the forces have their lever arm decreased and thus the bending tendency is somewhat diminished. Some tension is also put on the rivet.

The stress as it is commercially figured for the shell, is not the exact stress that exists in the plant. A stress of 6000 pounds on the longitudinal seams is accompanied by a stress of 3000 pounds on the girth seams, and as these stresses are at right angles to each other the actual stress will be nearer to the resultant of the two. In the case in hand it will be

$$\sqrt{6000^2 + 3000^2} = 6700$$

pounds. We should proceed very cautiously when it comes to advocating a reduction of the factor of safety, or what amounts to the same thing, the carrying of a higher pressure on the boiler than the one assumed in its original design. It can be seen that the computation of stresses in a boiler under internal pressure is only approximate, and the only reason that exists for figuring boilers as we do, is because we have had a moderate degree of success in so doing.

From the foregoing the following conclusions may be drawn:

First. In order to prevent a superheating of the water, the blowoff should be opened for a short time or the safety valve should be lifted when the boiler is considerably below its working pressure. A sudden rise in pressure will then probably not exceed the actual working pressure.

Second. Boiler shells should be formed hot and bent to a true circle and thoroughly annealed before final riveting so as to eliminate as much as possible all initial internal strains.

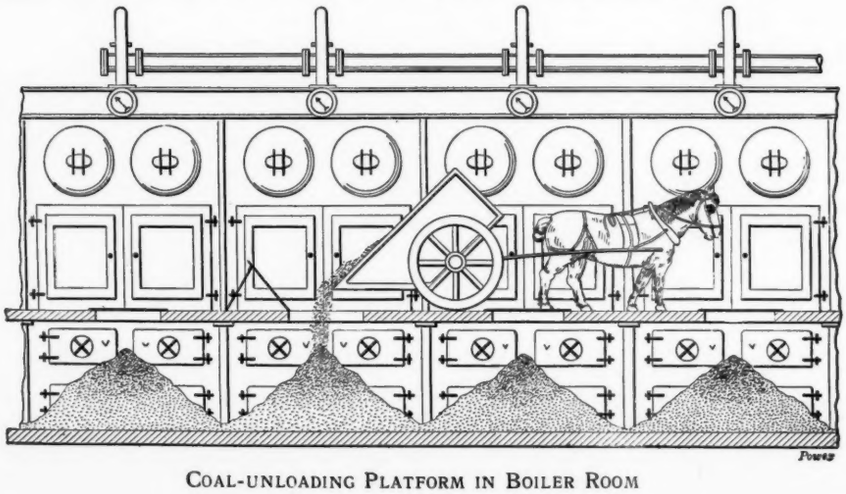
Third. Rivets should be driven hot, and with a pressure not more than experience shows to be sufficient to entirely fill the hole when cold.

Fourth. Lap-riveted joints should not be used for longitudinal seams on boilers. The double butt-strap joint is essential, and should have inside and outside plates of equal thickness to prevent eccentric loading. The plates should be bent to their respective contours on the inside and outside of the boiler shell.

In conclusion, it might be mentioned that there are a number of other abuses that a boiler may be subjected to, but as they are self-evident, they need not be taken up here.

Novel Method of Delivering Coal

The problem of coal delivery to a boiler room is sometimes difficult to solve, and frequently novel devices and peculiar arrangements are used.



COAL-UNLOADING PLATFORM IN BOILER ROOM

At one power plant the boiler-room floor is about 12 feet below the street level. The coal is delivered in wagon loads and owing to the surrounding buildings can be delivered to the boiler room only at each end. This necessitated wheeling the fuel to the central boiler.

In order to deliver the fuel in front of all the boilers, of which there were twelve, a trestle platform was built, extending the entire length of the boiler room, and strong enough to safely hold a two-horse team and load of coal. In front of each boiler a trap door was hung on strong hinges.

The wagon is stopped at the proper place and the trap door lifted. The coal is then dumped and falls through the opening to the floor below. Then the trap is closed and the wagon pulled off at the opposite end from which it entered.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment.

Induction Motor Hand Starters

By R. H. Fenkhausen

The subject of induction-motor control may be divided for convenience into four divisions:

1. Hand control for constant-speed service.
2. Hand control for varying-speed service.
3. Automatic control for constant-speed service.

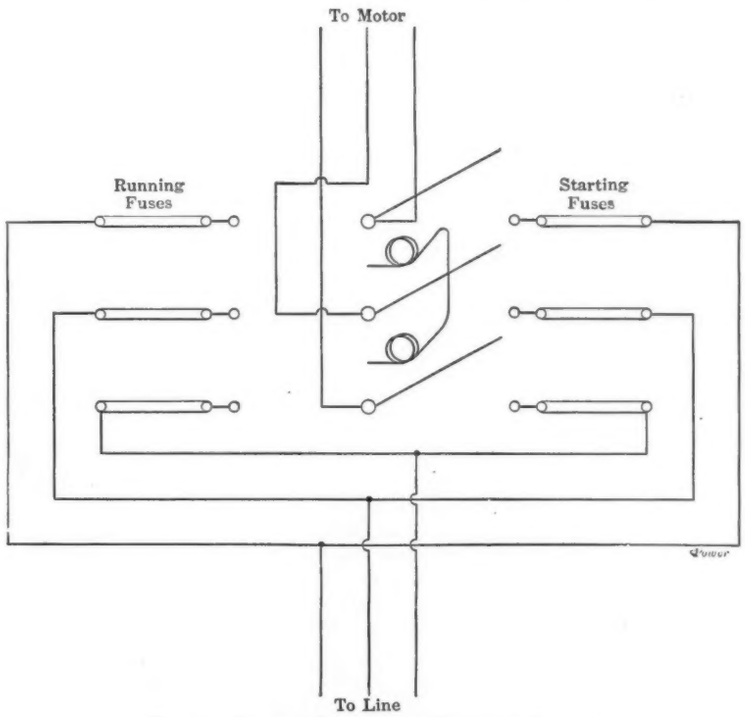


Fig. 1. Safety Spring on Starter Switch

4. Automatic control for varying-speed service.

The present article is confined to the consideration of apparatus commonly used for hand control in constant-speed service.

Squirrel-cage Motors

As the type of constant-speed induction motor most widely used is the squirrel cage, the control apparatus adapted to this type of motor logically comes first in the list. Squirrel-cage motors not exceeding 5 horsepower in size require no other starting device than the main line switch and may be started with full voltage on the primary winding. When started in this manner five or six times the full-load current is required to exert full-load torque. As the fuses required to carry this heavy starting current would be far too large to protect the motor when running, it is advisable to install a double-throw switch and two sets of fuses, one for starting and the other for running. The side of the double-throw switch equipped with the heavy fuses for starting should be provided with a spring placed so as to prevent a thoughtless operator from leaving the motor running with the starting fuses in circuit. This arrangement and the switch connections are shown diagrammatically in Fig. 1. When circuit-breakers are used instead of fuses, a tap may be taken off the overload coil of the circuit-breaker as in Fig. 2, the connections being such that fewer turns are in circuit during the starting period.

Squirrel-cage motors of more than 5 horsepower are almost invariably started with reduced voltage on the stator winding in order to prevent taking such a heavy starting current as to cause objectionable voltage fluctuations in the supply system; and also to reduce the heavy strains that would occur in shafting, belts, etc., were the motor forced up to speed suddenly.

Starting with Reduced Voltage

Four methods of reducing the voltage applied to an induction motor are available:

1. Special low-voltage taps from the supply transformers.
2. Star-delta or series-parallel connection of the stator windings, as represented in Fig. 3.
3. Noninductive resistances in series with the divisions or "phases" of the stator winding.
4. Autotransformers (commonly called compensator starters when used for motor starting).

The first method is applicable only when the motor is supplied from transformers situated nearby and as a 50 per cent. tap is the only one likely to be available in standard transformers, only one magnitude of starting torque can be obtained.

The second method requires that several extra leads be brought out of the motor frame, and, besides, is open to the same objection as the first method

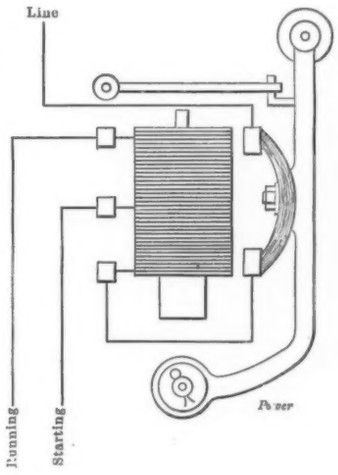


Fig. 2. Starting Tap on Circuit-breaker

that only one starting voltage (50 per cent. in a two-phase and 57 per cent. in a three-phase motor) is available. Where the required starting torque is not excessive this is not a serious objection, but in service where the starting load is liable to be heavy, some other method of starting should be adopted; otherwise an increase in the load may prevent the motor from starting and leave no other recourse than the installation of a large motor.

Resistor Starters

The third method has been the subject of much argument in the technical periodicals. Its advantages are light weight, simplicity and a greater number of starting points than any other method possesses, resulting in more gradual starting and uniform acceleration of the load. Fig. 4 illustrates the Allen-Bradley resistance starter which has recently been brought out. This starter utilizes the property possessed by graphite or carbon of widely varying its electrical resistance under different degrees of pressure. Columns of graphite disks inclosed in an enameled-iron tube are gradually compressed by the starting lever until their resistance is negligible and a slight further movement of the lever short-circuits the columns and connects the motor directly to the line. As the available resistance variation is about one hundred to one and there are no "steps," a very sensitive control of the motor current is possible during the starting period. This feature is particularly valuable when large belts are being put on or where for any reason it is desirable to move the motor through a definite fraction of a turn. The principal disadvantage of the resistance starter is the amount of energy wasted during the starting period, but this disadvantage is more a theoretical than a practical one, as a little consideration will show. The power wasted in a resistance starter is in watts or useful power, whereas the current taken by an autotransformer is largely wattless; therefore, although the power in watts taken by a resistance starter is much greater than that taken by an autotransformer, the current in amperes is nearly the same, and the line disturbance is practically equal in both cases. As the amount of power wasted while starting is negligible in all ordinary cases, the resistance starter is not objectionable on that score and in many cases it gives satisfaction where no other type of starter would.

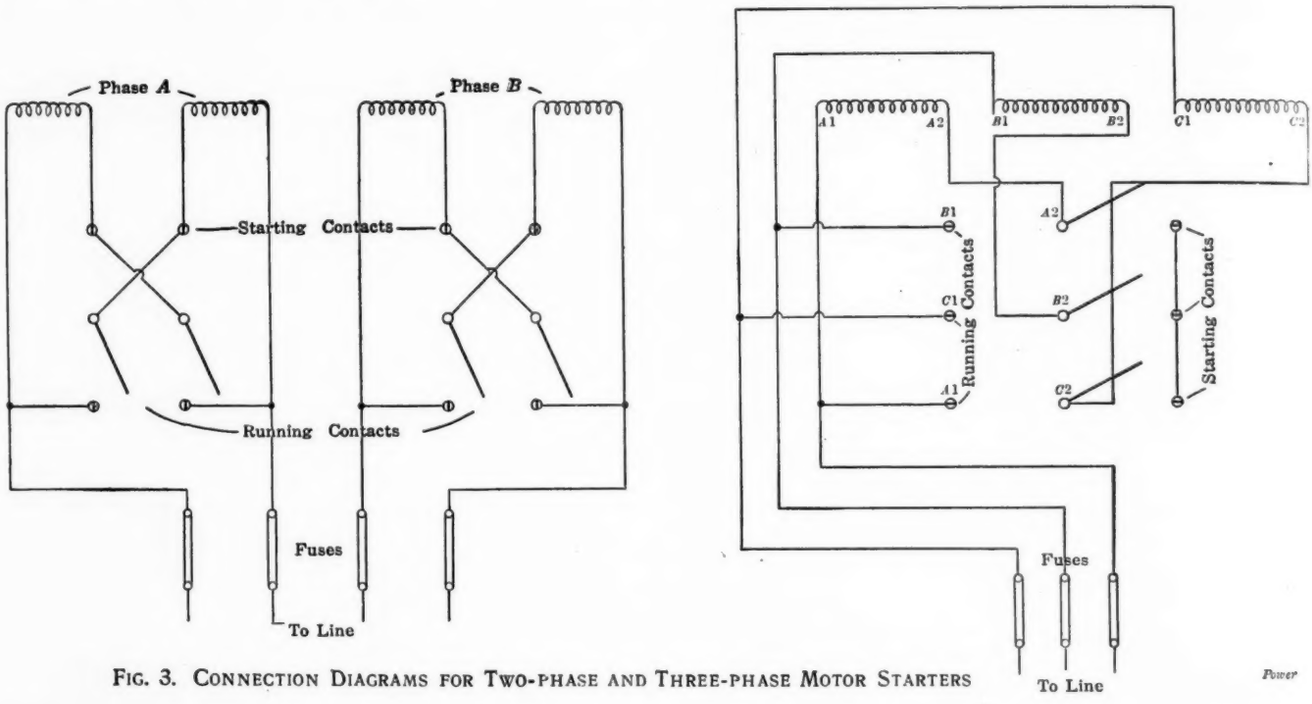


Fig. 3. Connection Diagrams for Two-phase and Three-phase Motor Starters

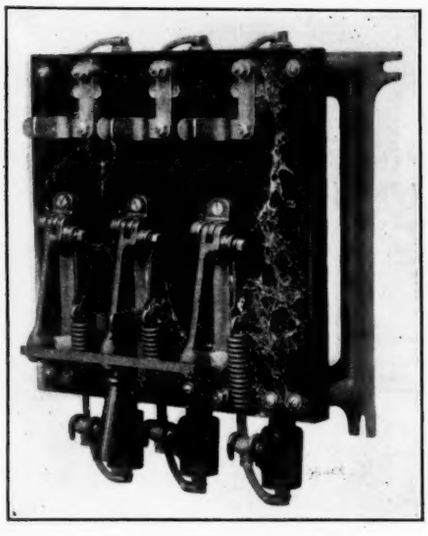


Fig. 4. Starting Switch with Graphite Resistors

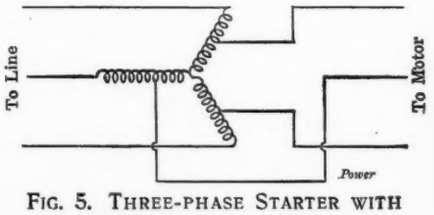


Fig. 5. Three-phase Starter with Three Autotransformers

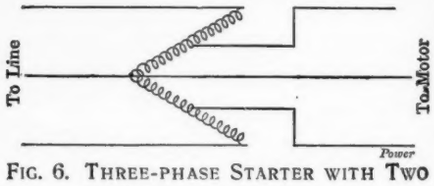


Fig. 6. Three-phase Starter with Two Autotransformers

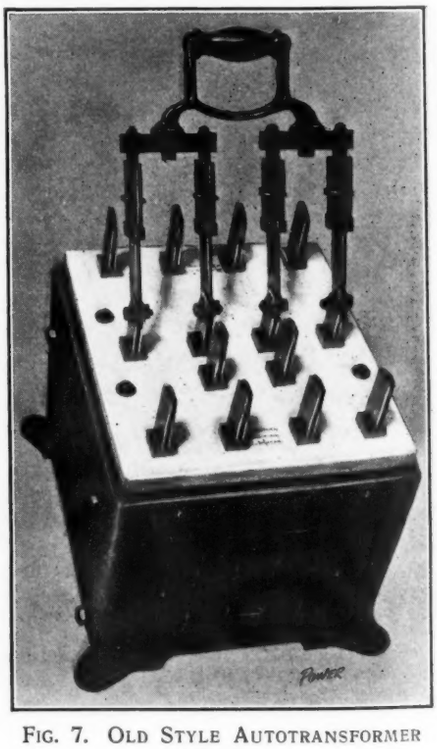


Fig. 7. Old Style Autotransformer Starter

Autotransformer Starters

The fourth method is most extensively used at present. Most of the autotransformers now built for starting motors of 50 horsepower and less have but one

starting point. Several taps are brought out from the autotransformer, however, so that several starting voltages are available. These taps are accessible by taking off the starter cover, and by trying successive connections the voltage best adapted to the case in hand can be determined. Care must be used that the transformers are connected alike on all phases. For two-phase work two autotransformers are used. For three-phase work either two or three may be used, as desired.

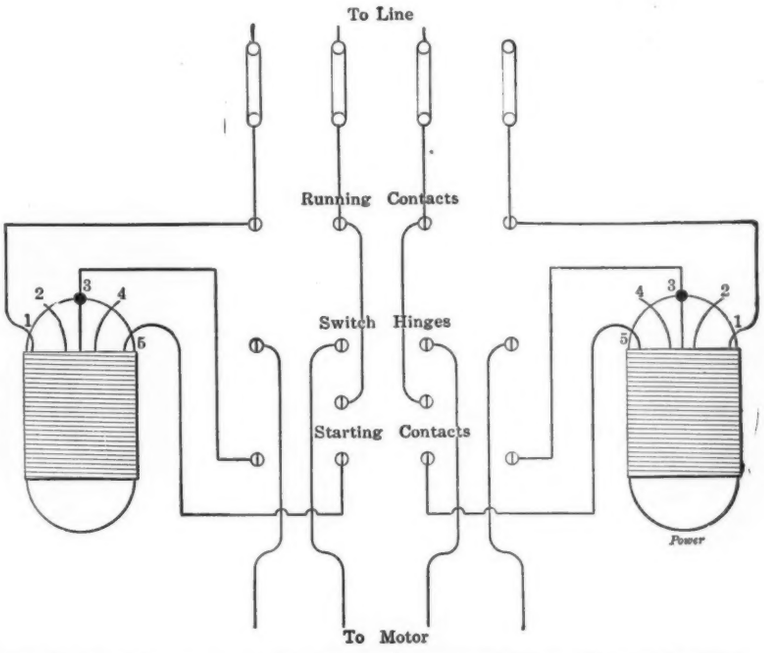


FIG. 8. CONNECTIONS OF TWO-PHASE AUTOTRANSFORMER MOTOR STARTER

The standard practice of the General Electric Company is to use three autotransformers for all three-phase starters up to 50 horsepower, connected as in Fig. 5. The Westinghouse Company, on the other hand, uses but two autotransformers for both two-phase and three-phase motors (Fig. 6), a standard two-phase starter being connected in V or open delta for three-phase motors. The first starter of the autotransformer type that came into extensive use is the form shown in Fig. 7. This has long since been superseded by autotransformers equipped with oil-break switches, which are now furnished by all motor builders; but as many thousands of the old starters are still in use, the internal connections of this form are shown (Fig. 8) for the benefit of those who are still operating this type of apparatus.

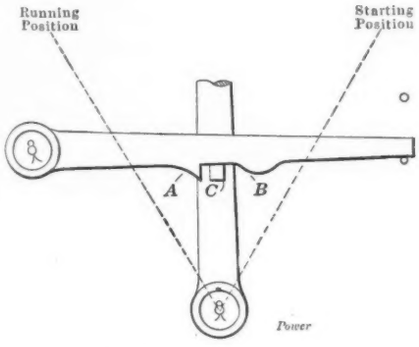


FIG. 10. SAFETY LATCH

Most of the types of autotransformer starter now manufactured are so arranged that the operating handle may be moved from the running to the "off" position without passing through the starting position, thereby reducing the sparking at the switch contacts. The simplest method of accomplishing this is by locating the "off" position in the center of travel and the starting and running positions one on each side. This method is open to the objection that a careless attendant can throw the handle directly to the running position, with consequent danger of injury to the motor and its connected shafting, etc. On the General Electric starter, Fig. 9, there is an ingenious device to prevent this. A notched locking bar, Fig. 10, rests upon a projection attached to the operating lever of the starter. The square shoulder at *A* prevents the lever from moving toward the running position. The rounded projection at *B*, however, offers no obstacle to the movement of the lever toward the starting position. Once the motor is up to speed, the operating lever may be thrown to the running position by a quick movement, because the projection *C* on the operating lever will, in passing under *B*, throw the notched bar upward, and the operating lever will have passed under the shoulder *A* before the bar falls again. If the operator attempts to move the lever slowly from the starting position to the running position, the shoulder *A* will prevent it from passing the "off" position and a new start will be necessary.

The internal connections of a two-phase starter of this type are shown in Fig. 11. It will be noted that an extra set of fuses are cut into circuit when the handle is moved to the running position. When this type of starter is used on a two-phase three-wire system, great care must be exercised in selecting the proper pairs of leads to be connected together for the common return. If this is not done there is great danger of a short-circuit being formed and consequent destruction of the starter. As previously stated, a different starter for three-phase motors is made, but for emergency use the two-phase starter connected for three-wire operation may be used with three-phase motors. In this case, however, the running fuses will all be of the same capacity, whereas for two-phase three-wire circuits the common-return fuse must be 40 per cent.

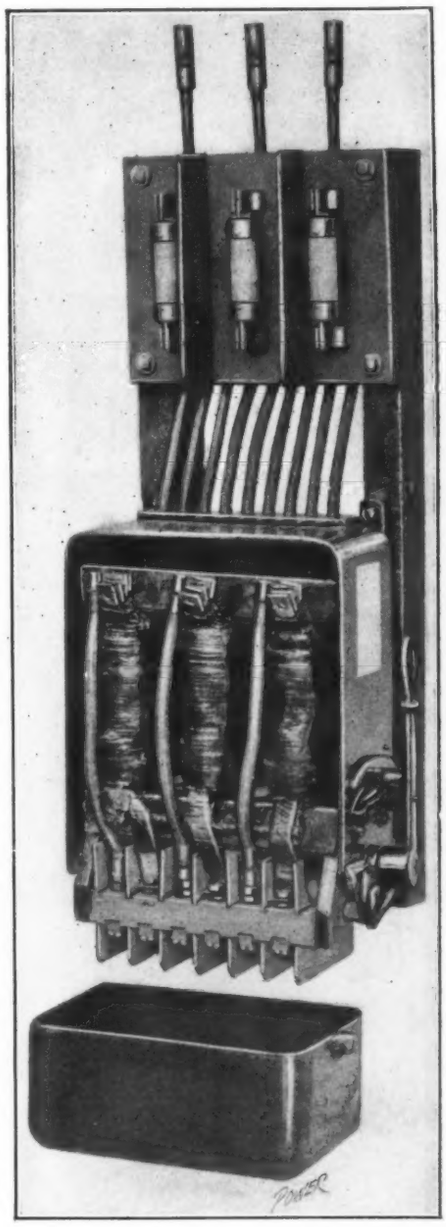


FIG. 9. MODERN THREE-PHASE STARTER

larger than each of the other two. In Fig. 11, the proper leads to connect for three-wire service are designated *L X*,

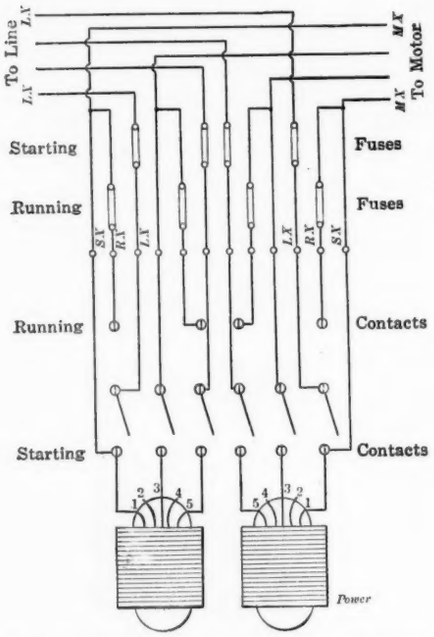


FIG. 11. CONNECTIONS FOR STARTING AND RUNNING FUSES

S X and *R X*, meaning "line," "starting" and "running," respectively.

The starter shown in Fig. 12 is the

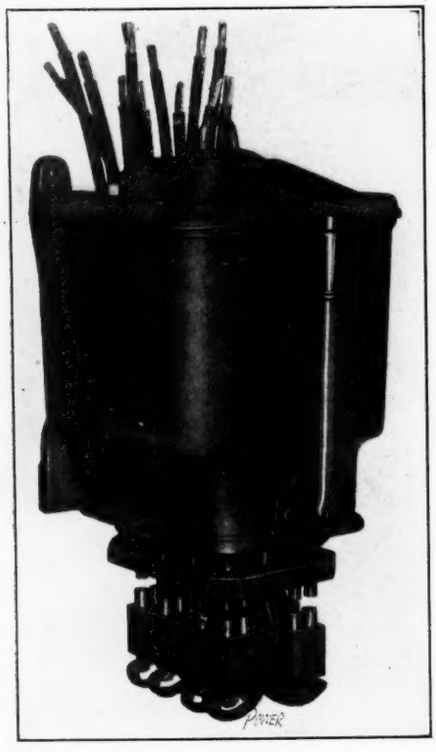


FIG. 12. TWO-PHASE STARTER WITH BUTT SWITCH

latest type produced by the Westinghouse Company. The "off" position is in the center of the lever travel and in addition to a device similar to Fig. 10 to prevent movement to the running position first, there is attached to the operating lever a spring tending to return it to the "off" position. The lever is held in the running position by a latch but, there being no latch in the starting position, there is no chance for the motor to be left running with the lever in the starting position. Spring-operated butt contacts of copper and brass, shown near the bottom of Fig. 12, are used in this starter in-

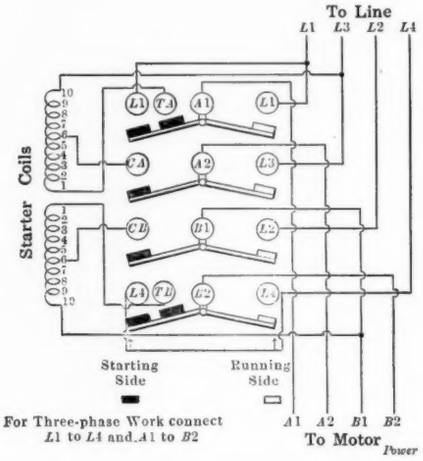


FIG. 13. CIRCUIT DIAGRAM FOR FIG. 12

stead of the familiar drum and finger contacts, and the makers claim greatly increased life of contacts due to their use. The internal connections of this starter are shown in Fig. 13.

Generators with Commutating Poles

BY ALVIRTIS S. SALKELD

Commutating poles are generally used on direct-current machines designed to carry a widely variable load. They furnish the necessary flux to neutralize the effect of armature reaction, which would otherwise shift the electrical neutral point between no load and full load. This flux also assists the reversal of the current in the coil during commutation.

A certain number of ampere-turns is required on the intermediate poles to secure proper commutation, and in order to make it possible to get exact excitation, a shunt is provided across the terminals of the interpole winding. This shunt is usually a noninductive strip of german silver, which is unsuitable for rapid load changes. For instance, suppose the load suddenly increased to full load or more; the heavy current, instead of going through the commutating field winding, would be forced through the noninductive german-silver shunt, on account of the inductance of the field winding, allowing the electrical neutral to shift and cause bad commutation. To prevent this, an inductive shunt should be used on all machines of 200 kilowatts or over, and with a voltage of 500 or more. An inductive shunt consists of insulated copper strip wound around a laminated iron core divided into two parts so that the inductance of the shunt may be changed by separating the two core members more or less.

As a test is required to determine the amount of current to be shunted from the commutating-pole winding, it is best to give the inductive shunt a greater inductance than that of the commutating pole, a low resistance and an ample current-carrying capacity. If any extra resistance is needed, a german-silver strip may be connected in series with the inductive shunt, and by changing the length of the german-silver strip the total shunt resistance necessary to give the desired commutation through the range of load for which the machine was designed may be obtained.

When satisfactory commutation has been obtained, try throwing the load on and off suddenly. If violent sparking or flashing occurs, the airgap of the inductive shunt should be readjusted. If an ammeter connected in the shunt circuit shows that the current quickly falls to zero when the load on the machine is suddenly thrown off, there is too little inductance in the shunt, and the airgap should be decreased.

LETTERS

The Sweeper Should Have Been Promoted

It happened at one of the power plants in a coal-mining town. Two alternating-current generators were running in parallel to supply power to operate the mining machinery. The alternators were driven each by a horizontal cross-compound engine. One of the low-pressure cylinders became disabled, making it necessary to stop the engine, and the engineer hastily shut the throttle without disconnecting the generators at the switchboard. The generator of the disabled engine kept revolving, of course, taking current as a motor from the busbars. The engineer sent his assistant to shut off the valve in the steam line in the boiler room, but the engine would not stop. Then the engineer sent for some bars and timber, intending to use them to brake the flywheel in order to stop the engine and generator. An Italian, who was employed as sweeper in the engine room, was watching all the time but said nothing until he saw the men about to "brake" the engine; then he touched the engineer on the arm and said: "Mister, pulle de switch, pulle de switch." This corrected the trouble.

The chief engineer has moved.

W. H. KELLER.

Charlestown, W. Va.

Gas Power Department

Willans & Robinson's Two Stroke Cycle Engine

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men.

We illustrate herewith a design of internal-combustion engine, working on the two-stroke cycle, which has been evolved by the well known English firm of Willans & Robinson, pioneers in high-speed steam-engine design. The piston acts as a valve with respect to the inlet ports, as usual, but it is supplemented by a concentric sleeve reciprocating between the piston and the cylinder wall. This sleeve is perforated by two sets of ports which at the end of the working stroke coincide with the inlet and exhaust ports in the cylinder. The sleeve is actuated by means of eccentrics on the crank shaft. The piston works within the sleeve and of their downward strokes and similarly at the ends of their upward strokes at nearly the same time; preferably the eccentric actuating the sleeve is set 15 degrees in advance of the piston crank, so the length of the travel imparted to the sleeve is about half the length of the piston stroke. The stroke of the sleeve and piston are in phase, or nearly so; that is, the sleeve and piston arrive at the ends that the exhaust ports are opened just before the opening of the inlet ports.

Referring to Figs. 1 and 2, which show sections taken at right angles to each other with the various parts in different positions, *A* is the cylinder in which a sleeve *B* is reciprocated by means of eccentrics *C* on the crank shaft *D*, a rod *E* connecting each eccentric to the sleeve. The piston *F* reciprocates within the sleeve *B*. The cylinder head is made with a cylindrical projection *G* which extends within the sleeve *B* and is provided with packing rings. In the sleeve *B* are two rings of ports, one ring *H* toward the inner and one ring *I* toward the outer end, and there are in the cylinder wall corresponding ports *J* and *K* which coincide with the ports *H* and *I* at the end of the working stroke. At the end of the upward stroke, the outer ring *I* of ports has passed above the packing rings of the projection *G* and the packing rings of the piston *F* have passed above the inner ring *H* of ports in the sleeve, as shown in Fig. 2.

The explosion having taken place, the piston *F* and the sleeve *B* move downward, and toward the end of the stroke

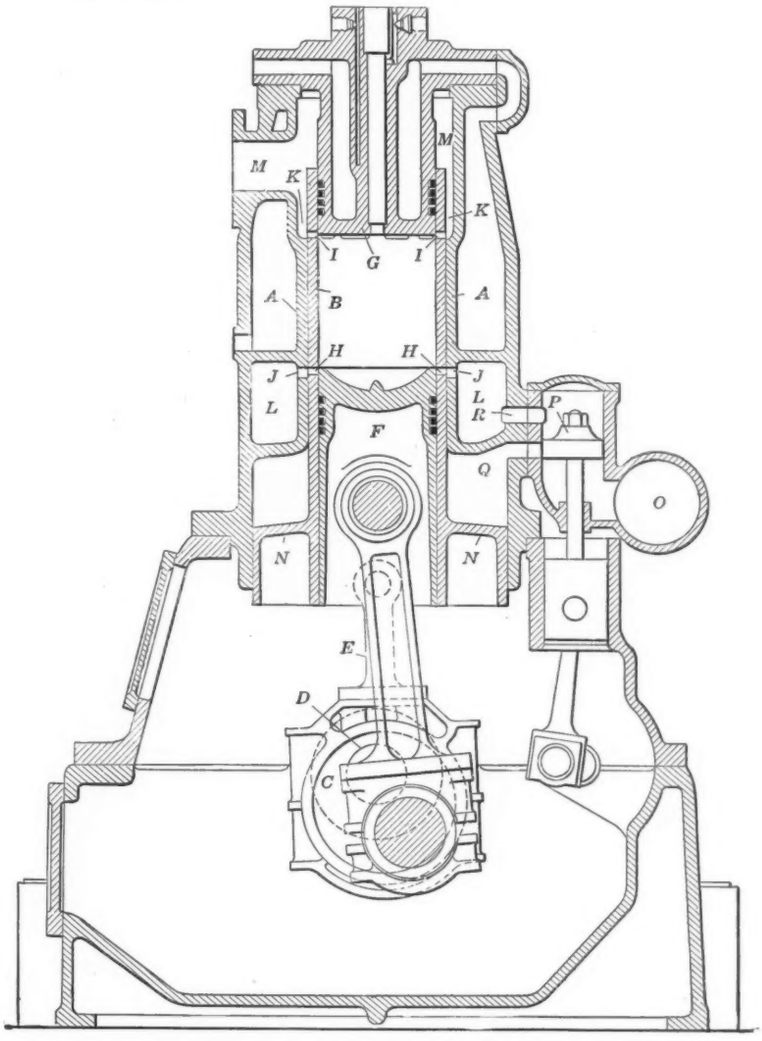


FIG. 1. WILLANS & ROBINSON TWO-STROKE CYCLE ENGINE

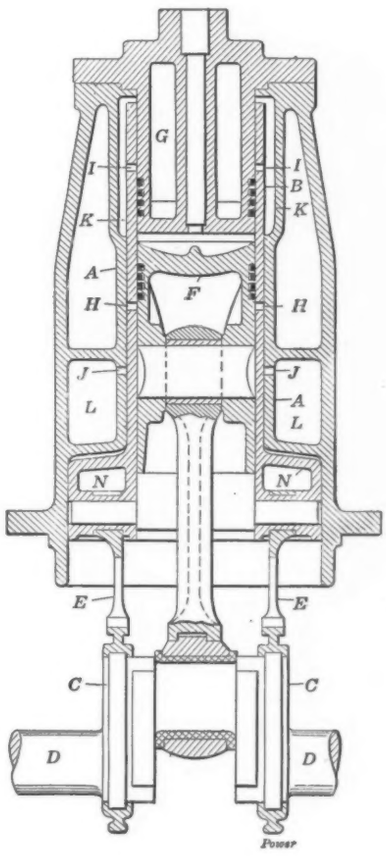


FIG. 2.

the outer ring *I* of ports in the sleeve passes beyond the end of the cylindrical projection *G* just before the piston *F* passes the inner ring *H* of ports in the sleeve, as shown in Fig. 1; at the end of the stroke the ports *H* are uncovered, and the ports *J*, leading to an annular receiver chamber *L*, are opposite the inner ports *H*. The ports *I* in the upper part of the sleeve *B* communicate always with an annular passage *K* leading to the chamber *M*, whence the exhaust gases pass out. Scavenging air is blown through the annular space or receiver chamber *L* and through the ports *J* and *H* into the interior of the sleeve, which is really the work space of the cylinder, and the products of combustion are blown by the scavenging air through the ports *I* and the annular passage *K* into the exhaust chamber *M*.

On the return stroke the air contained in the sleeve is compressed as the piston approaches the cylinder head. With an engine of the Diesel type the fuel is injected in the usual way at the commencement of the following or working stroke; with a gas or gasolene engine, the fuel is introduced with the scavenging air at the end of the downward stroke.

For providing the scavenging air an annular piston *N* is formed on the inner end of the sleeve *B*, working in an enlarged part of the cylinder bore. Air enters from the pipe *O* and is admitted to the enlarged part of the cylinder by the piston valve *P*, controlling a port *Q*. On the upward stroke, air is driven by the annular piston *N* through the ports *Q* and *R* into the receiver *L*, the piston valve *P* being then below the port *Q;* and at the end of the next downward stroke of the piston *F*, air from the receiver *L* will be blown through the sleeve for scavenging and charging purposes, as already described.

We are indebted to *The Mechanical Engineer*, of Manchester, Eng., for the illustrations and the foregoing particulars.

The Gas Turbine

By F. R. Low

The gas turbine about which most is known in the United States is perhaps that of Armengaud & Lemale, of Paris. I had the privilege recently of an interview with M. Marcel Armengaud, who, since the decease of his brother René, in 1907, has been the managing director of the Société des Turbomoteurs. He is a consulting engineer and patent attorney with a large practice, a graduate of the University of Zürich, where he studied under Stodola, and was one of the French commissioners to the St. Louis Exposition in 1904. Besides continuing the researches of his brother with regard to the internal-combustion turbine he is devoting attention to aviation.

"As you know," he said, "we attained a considerable success with the turbines which we built, but our little company has not the capital necessary to undertake their manufacture, nor even to continue to experiment upon a large scale. We have, however, furnished two turbines, one of 150 and one of 200 horsepower to different builders of torpedoes for the propulsion of which their extreme compactness and lightness make them particularly adapted. The 150-horsepower size with all its fittings and fuel weighs not more than 100 kilos, less than a pound and a half per horsepower. Its speed is 15,000 revolutions per minute, reduced by gearing to 1500 turns for the shaft."

The turbine is operated by injecting kerosene, air and water into a closed chamber where combustion is maintained continuously. The 150-horsepower machine, when developing its full load in a shop test, used:

$$\left.\begin{matrix}122 \text{ grams of water}\\ 349 \text{ grams of air}\\ 17 \text{ grams of oil}\end{matrix}\right\} \text{ per second.}$$

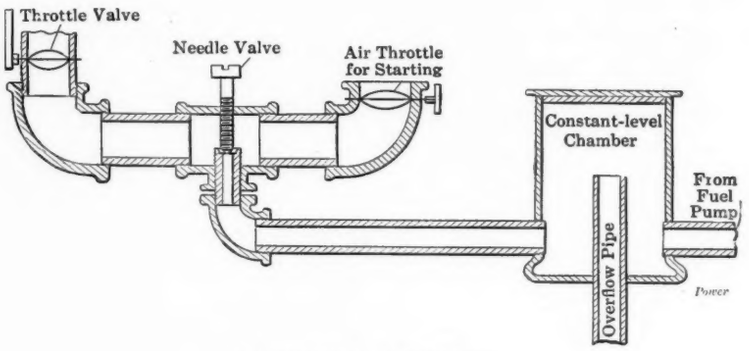
This is $\frac{17 \times 3600}{150} = 408$ grams (0.9 pound) of oil per brake horsepower. While this is considerably more than is required by high-compression reciprocating oil engines [Sulzer Brothers guarantee Diesel engines for 180 to 250 grams (6.4 to 9 ounces) per brake horsepower-hour] the turbine offers many advantages in reduced size and weight in continuous high-speed rotary motion, in silent action, absence of exterior moving parts and ease of operation, and Monsieur Armengaud has an abundant faith in its future. One of its advantages for applications such as that to the torpedo, where a supply of compressed air must be carried, is that it can use the air away down to a pressure of seven atmospheres or less while the high-compression engine stops when the pressure is still some 30 atmospheres. The turbine, too, can get along with a smaller quantity of air. The present practice with the Armengaud & Lemale turbine is to maintain the pressure in the combustion chamber at about 70 pounds above the atmosphere and to maintain the temperature of the gas after expansion at about 650 degrees Fahrenheit. More or less water may be used according to conditions, the desideratum being to use only enough to prevent a destructive temperature. The efficiency increases as the supply of water is restricted and the temperature allowed to rise.

The principal incubus of the gas turbine at present is the air compressor. To furnish the large volume of air required under considerable pressure requires a machine more massive than the turbine itself. The recent development of the centrifugal air compressor by Professor Rateau and others points to possibilities in this direction which may result in the reduction of the compressor to the simplicity of the turbine itself and permit its being made integral with it. Monsieur Armengaud has proposed and intends to develop a compressor upon the impulse principle which ought to result in the same reduction in number of stages and thus in weight and bulk that the impulse turbine offers over that of the reaction type and which has led to the very common use of impulse wheels for the initial stages of reaction, or Parsons, turbines, cutting down their length and weight enormously.

CORRESPONDENCE

A Homemade Carbureter

The accompanying sketch illustrates the construction of a homemade constant-level carbureter for a gasolene engine. The apparatus is made up of pipe fittings. The overflow chamber is a 1½-inch pipe cap; the fuel pipe, overflow and pipe to the needle valve are of ⅛-inch pipe. The "standpipe" is a short nipple with the mouth at the upper end bored out tapering for the point of the needle valve. The suction and main throttle valves are round disks made of sheet brass; the main valve is 11/16-inch diameter, set in a ¾-inch pipe, and the suction throttle is 1 inch, in a ¾-inch elbow. All of the material did not cost more than half a dollar. The carbureter was made by a youngster who got his idea for the design from the U. S. Geological Survey Bulletin No. 277.



A Homemade Carbureter

James E. Noble.

Toronto, Can.

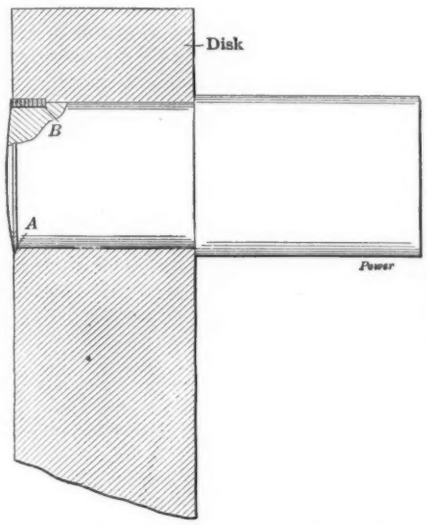
Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words, wanted.

A Loose Crank Pin

One evening when our engine was carrying about one-half load, the crank pin suddenly loosened and turned in the disk, breaking off the centrifugal oiler. Before the engine could be stopped the pin had worked out nearly ½ inch. As the engine was needed at once, the pin was repaired, as shown in Fig. 1, and was run until a new pin arrived. A hole was drilled and tapped out ⅜ inch at *B* and a plug screwed in to prevent the pin from turning. The crank disk was then countersunk at *A*, and the pin peened over to prevent it from coming out.

When the new pin arrived it was inserted in the following manner: The old



MANNER OF SECURING CRANK PIN IN DISK

pin being driven out, the hole was calipered and found to be true and the new pin was put in a lathe and turned down until it was 0.005 inch larger than the hole in the crank (0.001 inch being allowed for each inch of diameter of the pin). The crank was then put on the outer center and a brick forge built under it and heated with a charcoal fire, which was forced by compressed air until the crank was hot enough to melt a piece of solder put into the crank-pin hole. At this heat the pin was driven in square with a few blows from a sledge and when cold it was peened at *A*.

After a pin has been entered it must be quickly forced into place, as it is liable to expand and stick in the hole, which would mean drilling it out. If the hole in the crank is not round, it should be bored out, for if the pin is inserted and the hole is not true, the former will not remain tight.

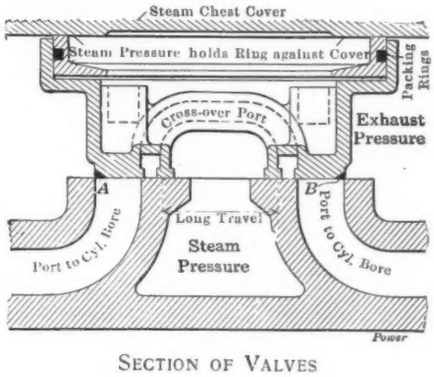
After this experience, I have seen to it that all crank pins were peened at *A* to prevent their coming out in case they should work loose. Generally when a crank pin works loose, it will cause a pound and give warning to the engineer, but this engine ran quietly until the pin began to turn in the disk.

R. L. MOSSMAN.

Tampa, Fla.

Curing a Knocking Slide Valve

A horizontal center-crank automatic engine, 19x18 inches, designed for 100 pounds steam pressure at the throttle, direct-connected to a 150-kilowatt 250-volt generator, gave the owners considerable trouble on account of knocking in the steam chest. The owners were so afraid to operate the engine that they were considering whether or not to shut it down until the trouble could be corrected. The chief engineer and two other engineers who were called in recommended a new valve in the steam chest, but I found upon



SECTION OF VALVES

examination that a new valve would not have corrected the trouble.

It seems that when the engine was purchased there was no feed-water heater in the exhaust line and the owners did not express any intention to install one. The engine was built, therefore, to give the best possible economy with a free exhaust to atmosphere. Later, an open-type feed-water heater was installed and some additional ells were put in the exhaust line from the engine. Then when the engine ran "light," the steam valve lifted off the seat near the end of every stroke of the piston, and reseated again with a clack as soon as the pressure under the valve was reduced.

The valve was removed and ⅛ inch filed off at the exhaust edges, as indicated at *A* and *B* in the accompanying cross-sectional sketch, and there has been no more knocking in the steam chest since then.

W. H. KELLER.

Ansted, W. Va.

Failure of Boiler under Test

The soundness of the Massachusetts boiler rules and the necessity that existed for their enactment were recently demonstrated at the Atlantic Works, East Boston, where a boiler that did not com-

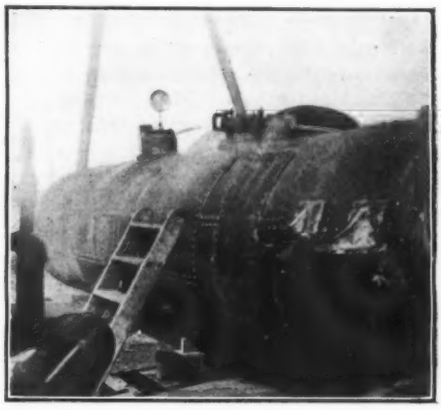


FIG. 1. BOILER JUST BEFORE FAILURE

ply with the requirements of the rules was, at the request of the owner, subjected to a hydrostatic test to ascertain the pressure required for its destruction.

The boiler was thirty years old and had been in service up to about three years ago, at which time the allowable pressure was 65 pounds. The specifications were as follows: Type, horizontal tubular; length, 19 feet 6 inches; diameter, 66 inches; thickness of shell plates, ⅜ inch; thickness of heads, ½ inch; type of joint, double-riveted lap seam. Pitch of rivets, 2 1/16 inches; tensile strength of plate, 60,000 pounds per square inch. The shell was made up of seven courses and was patched in several places, and in addition to the prohibited lap joint, the boiler embodied a number of features which are considered bad practice in Massachusetts. The nozzle and manhole ring were of cast iron, the manhole cover being bolted down to the outside of the flanged ring; the blowoff was located in the front head about 3 inches above the bottom of the boiler; and there was only one handhole, that being located in the

front head. Also, the fusible plug was placed in the third sheet on the side of the boiler.

The test was conducted under the supervision of chief inspector McNiel, assisted by district inspectors Evans and Luck, and resulted in distorting the third sheet to such an extent, when the pressure reached 350 pounds, that the cast-iron nozzle was unable to withstand the

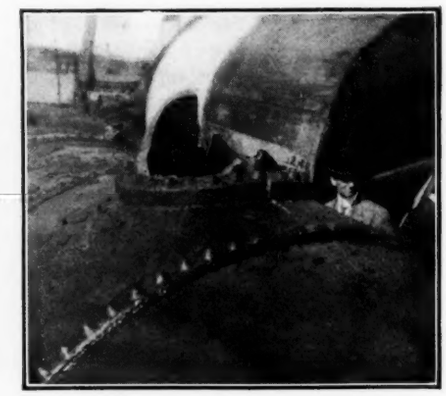


FIG. 2. BROKEN NOZZLE AND CRACKS IN SHEET

strain. Parts of the nozzle and the test gage were blown several feet in the air, falling into the harbor. The sheet cracked each side of the nozzle opening, the cracks being about 3 inches long and having a somewhat crystallized appearance. The heads and tubes remained intact, showing no appreciable effect from the pressure.

C. F. ADAMS.

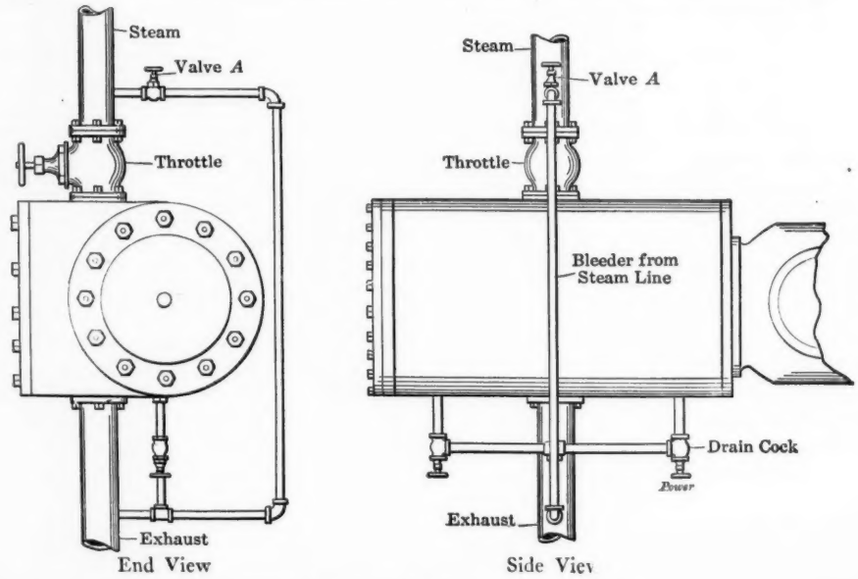
Lynn, Mass.

What Causes the Engine to Run?

We have a simple high-speed engine direct connected to a dynamo. The engine has an indirect balanced slide valve and the bleeders are connected as shown in the accompanying sketch. When the valve *A* on the bleeder is opened the engine starts and continues to run in the right direction as long as the valve is open. Will someone explain how this causes the engine to run?

E. R. TEER.

Anderson, Ind.



CYLINDER SHOWING BLEEDER CONNECTIONS

Trouble with Metallic Packing

I am in charge of a 100-horsepower, 12x12-inch, high-speed engine, which was packed with metallic packing when I took charge, over a year ago. The packing, which was a soft metal in small grains, containing considerable graphite, was put in sacks and placed in the packing box with a copper wire around the piston inserted before it and a ring of fiber packing put in afterward.

The packing gave no trouble during all last year and the engine ran nicely, but after being idle for about three months this summer and started again this fall, the packing began to leak and was tightened only slightly, because, if it had been tightened much the piston rod would have become hot. This only partially stopped the leak but as there was no more packing on hand, we just let the engine run with the small leak. In a day or so we began to notice a knocking inside the cylinder which sounded as if the piston were hitting the head. This kept getting worse until upon stopping the engine and taking off the head we found a small handful of the packing in the back end of the cylinder. This was taken out and the head put back into place, after which we expected to see the engine run all right again; but not so. At times it would knock quite hard, then run smoothly for a while, then begin the knocking again. Finally it became noticeable that while the knocking was going on, the leakage through the packing was greater. Hence we stopped the engine and prepared to take out the old packing and put in new. Another handful of the packing was taken out of the back end of the cylinder, this being mashed in the ring grooves which hold the rings in place, and much of it was stuck fast to the piston. The piston and rings were cleaned and new packing put in and the engine ran all right.

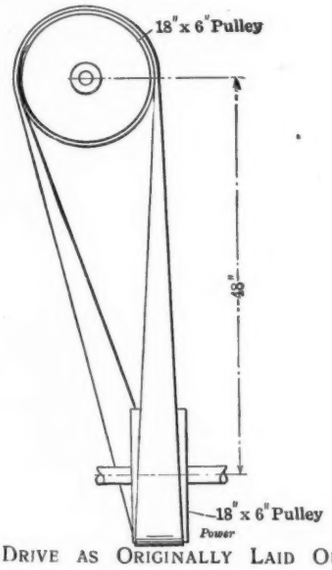
I believe metallic packing of this kind should not be tightened after it is once set. If it begins to leak badly, new packing should be put in.

E. V. CHAPMAN.

Decatur, Ill.

A Quarter Turn Drive

Recently I was assigned the work of laying out and constructing a drive for a swing saw, a circular saw, a boring mill and a nigger head, to be used by a contracting firm which was erecting a reinforced-concrete building. The manner in which the contractor desired the machinery placed necessitated a quarter-turn drive. A "mule stand" was out of the question on account of its cost, the lack of space, and the fact that the drive was



DRIVE AS ORIGINALLY LAID OUT

wanted for three months' use only. So we made a layout of a direct quarter-turn drive, as shown in the accompanying sketch.

When the drawings were completed, it was found that the distance between centers of the 18x6-inch pulleys was just 4 feet. On the drawing this did not look small, but when I turned the drawing over to the master mechanic for approval, he studied it for a while, and after advising me not to have a high belt speed, finally approved the layout, and we began to erect it.

When the construction was nearly completed the distance between centers

looked so insignificantly small that I was in doubt as to whether the drive would run satisfactorily, so I looked up various handbooks on the subject and found only one which contained any definite information; this advised a minimum angle of 25 degrees for the belt, or a distance of twice the diameter of the largest pulley, which, in this case, would have been 36 inches; but we already had 48 inches. However, it gave no information relative to the size of belts or belt speeds. Ours was a 6-inch single belt running at 1600 feet per minute. Upon showing this information to the master mechanic, he decided to risk it, but advised the use of a 4-inch double belt instead of 6-inch single belt. Upon going out to the job, however, I found the contractor skeptical; he did not like the idea of running the risk. So he ordered that the shed be raised and a new layout substituted.

When I went back to inform the master mechanic of the changes that had been ordered by the contractor, I was unable to get in touch with him, and the next morning he noticed the changes being made. I was called in and was censured for allowing the contractor to alter our original plans, as it made us look like a lot of amateurs in the eyes of the contracting firm.

My object in writing this is to ascertain first, what is the minimum allowable distance between centers of pulleys for a quarter-turn drive of this sort; second, what is the maximum belt width in inches; third, what is the maximum allowable belt speed?

WALTER J. BITTERLICH.

Watertown, Mass.

Feeding Boilers through the Blowoff Connections

An incident recently came to my attention which illustrated what a resourceful engineer can do to prevent a shutdown. It was at the plant of a large industrial concern, where the boiler-room equipment consisted of four 150-horsepower return-tubular boilers, which were fed by an ordinary duplex pump, discharging through a manifold into the different feed lines entering the boilers.

About the middle of the forenoon one day, the fireman accidentally twisted one of the valve stems from its seat, leaving the valve, which was of the gate type, wide open. This brought about an awkward condition of affairs as there was no means of regulating the water level in that boiler and it could not be spared long enough to be cut out of service for replacing the broken feed valve. Water rose rapidly in this boiler while the water level in the other boilers was so low that it was not possible to stop the pump.

Fortunately, the chief was a resourceful man and did not permit himself to become excited. A shutdown was next to impossible; even the loss of one boiler would practically necessitate it. Water was already too high in the one boiler and too low in the others. Therefore, he disconnected the main line of the blowoff pipe and put a globe valve on it, which he closed. The blowoffs from all the boilers were connected with this line, and by opening all of them all the boilers were connected together through the medium of the main blowoff line. The fire under the boiler with the broken feed valve was then forced considerably harder than the rest, and no more difficulty was experienced in maintaining the proper water level as water was easily forced into the other boilers.

Of course, the needed repairs were made when the plant was shut down for the night. It might be stated that the plug cocks in the feed lines between the check valves and the boilers were located on top in a practically inaccessible position for such a purpose as regulating the water supply.

EDWARD T. BINNS.

Philadelphia, Penn.

Metal for Cylinders

The question arises from time to time as to the most suitable metal for steam cylinders, and it appears that, although foundrymen agree on a certain grade, they do not always produce a metal which wears as well as desired. It is agreed that cylinders should be of hard, close-grained gray iron, but in some cases, although the grain appears fine, more lubrication is required than with others of apparently the same grade. As a general thing, the cylinder which requires considerable lubrication does not acquire the high polish necessary to economy in operation. It is not uncommon for different cylinders on the same engine to vary in grade; therefore, their length of service, before reboring is necessary, also varies. It may be answered that there are other elements influencing wear, not due entirely to the composition of the metal, but experience has shown that the principal factor is the metal.

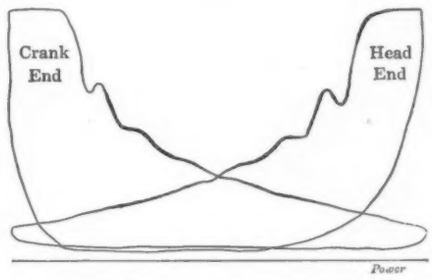
This leads to a consideration of a suitable metal for "bull rings" of pistons, and as to whether they should be of harder or softer composition than the cylinder. Some urge the use of a metal containing a small percentage of manganese; but what is the percentage? Can such a metal be machined readily and will it take a high polish? Others advocate the use of a mixture of steel and iron in casting; and still others claim that charcoal iron is the best. This would indicate that no fixed standard is used, but as every engineer has to renew pistons it is desirable that he should know and be able to specify the composition of the metal most suitable for his purpose. As an instance of this a certain foundry cast a set of rings for a large engine; the rings wore about 1/16 inch a week, and were replaced by rings of apparently the same composition and cast by the same foundry, which have been in service for four years without any perceptible wear.

W. E. RECTOR.

Brooklyn, N. Y.

Diagrams for Criticism

Will some reader of POWER kindly point out what the jagged expansion line in the



DIAGRAMS SHOWING JAGGED EXPANSION LINE

accompanying diagrams indicate? I am reasonably sure that there was no trouble with the indicator and think the trouble must be in the engine.

H. T. FRYANT.

Memphis, Tenn.

A Problem in Hot Water Heating

In the building of which I have charge, there is a hot-water heater located at the extreme end of the building, resulting in long horizontal runs before the water reaches the risers. Consequently, I have experienced much difficulty in obtaining a good circulation in the lines farthest from the heater.

I suggested to a heating engineer that if a pump were placed on the circulating line where it enters the hot-water tank a better circulation would result. But he claimed that this would create a vacuum in the branch lines near the top of the system, due to the fact that the pump would increase the pressure above that which is carried on the house tank, this being a closed tank in the basement of the building, and carrying 90 pounds pressure. He contended that the pressure must be reduced below that of the house tank before the cold water would enter. On this point I agree with him, but I do not believe that the pump would create a vacuum before that would occur.

The proper place to install a pump, according to his idea, is on the lines leading to the house tank from the hot-water tank.

I would appreciate opinions regarding this problem.

G. L. LYONS.

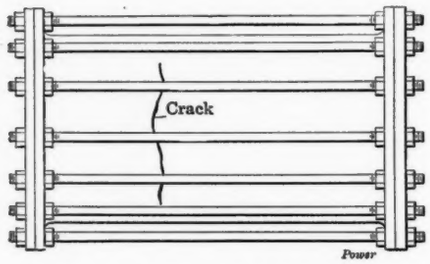
New York City.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues.

Cracked Cylinder

In response to Mr. Harrison's inquiries in the September 20 issue, I herewith indicate how the cylinder of a 30x66-inch engine was once repaired. The steam



THROUGH BOLTS ON CYLINDER

pressure used in this engine was 185 pounds.

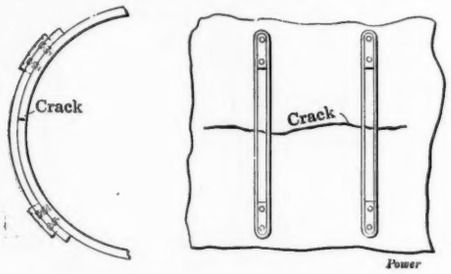
Long bolts were passed through the holes in the cylinder flanges, as shown in the accompanying figure.

H. R. BLESSING.

Philadelphia, Penn.

One way in which to repair a cracked cylinder is as follows:

Fit a piece of boiler plate carefully over the crack by heating the plate and hammering it to the proper shape. Cut an asbestos gasket for the patch and then bolt the patch in place with tap bolts. The patch should be 4 inches wide so as to



ARRANGEMENT OF LINKS AND BLOCKS

allow room for the bolts on either side of the crack. Space the bolts about 2 inches apart. The boiler plate used for the patch should be about ½ inch thick.

Another way in which to repair the crack is illustrated in the accompanying figure. Blocks of wrought iron or steel 3x1x4 inches in size and having rounded ends, are tap bolted to the side of the cylinder, as shown. Links of ¾-inch square iron are then fitted to the blocks and shrunk on. The links must be made of proper size so that they will grip the blocks tightly when shrunk into position. The holding bolts should be ¾ inch in size.

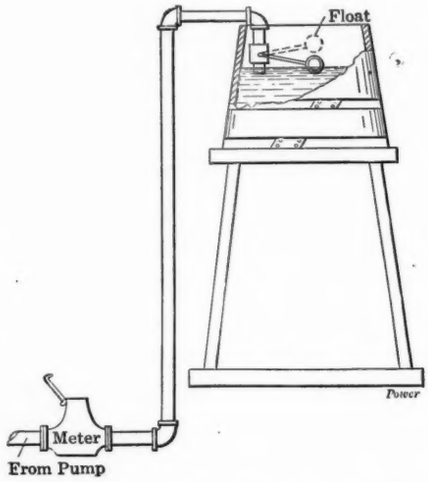
E. F. TRACY.

Mechanicsville, N. Y.

Accuracy of Water Meters

The variation in accuracy of the disk type of water meter is receiving some attention at the present time in the columns of POWER. It is quite well known that a disk water meter is just as capable of being inaccurate as is an electric meter. However, all in all, the disk meter is a fairly reliable instrument.

When a meter is small in comparison with the amount of water it is required to handle, it is very prone to read high.



ARRANGEMENT OF TANK AND METER

The disk meter is designed to work somewhat on the same principle as the plunger meter by measuring off small portions of the flow. I have found the disk meter to be quite reliable under moderate working conditions. But when it is overloaded, an overregister is almost sure to be made. While the plunger meter is quite accurate, at the same time it will not work under all conditions. I recall a case where one of the best known plunger meters was abandoned and a disk meter installed. The water had a peculiar chemical effect upon the linings of the plunger meter and it repeatedly failed to operate. A disk meter that is handling a large volume of water in proportion to its rating, when located in a main which is directly connected to the water-works pump, as is often the case, will work ahead on account of the action of the pump.

A case of this kind is shown in the accompanying figure. A large meter is connected into a large main carrying, say one-eighth of the volume of water which the pump will handle. The main delivers the water into a tank controlled by a float valve of the balance type. This meter does not have a steady continuous motion. The lower the float is the more the meter will register in excess of the quantity that is actually flowing. As the float approaches the position shown by the dotted lines, the meter becomes more accurate. This shows that when the water is flowing with the least amount of resistance the meter registers more than is passing. This and many similar experiences with the same type of meter makes it conclusive to me that a disk meter should be large in proportion to the amount of work done. If there are any vibrations in the line due to the working of the pump plungers it is a good plan to close down the delivery beyond the meter so as to afford some back pressure upon the disk of the meter and thus steady the movement of the disk.

C. R. MCGAHEY.

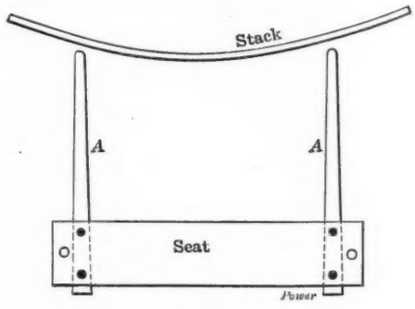
Sheffield, Ala.

Painting Smokestacks

The article on the above subject in the August 16 issue is very interesting, and should prove helpful to anyone who has stacks to paint.

The *modus operandi* of a practical steeple-jack painter who includes this district in his circuit is so simple and effective that his ideas are worth passing on.

Instead of two sets of blocks and tackle,



CONSTRUCTION OF SEAT

as described in Mr. Hawkin's article referred to above, this painter requires but one, and a handline of ¼-inch rope. The set of blocks, single and double, are rove with about 200 feet of ⅜-inch rope, and the handline is about 60 to 75 feet in length.

To attach the tackle to the first guy-wire band the painter gets as high as possible by means of a ladder placed on the roof, then he uses a few lengths of ¼-inch pipe to hoist the double block and its hook up to its position on the lug of the guy-wire band. A little U-shaped hook stuck into the top end of the ¼-inch pipe makes it easy to hook on the main hook, and also to detach the pipe rod.

Without any more preliminaries, when once this upper block is securely hooked in place, he is all ready to begin painting; for with his method, he paints *up* one side of the stack and *down* the other. There is thus no time or energy lost in initial ascents as in Mr. Hawkin's method.

Also, there is no need for a helper, as this painter has a device whereby he hoists himself easily and safely. It consists of two eccentric grips somewhat similar to wire stretchers; one is fastened to a breast belt, and the other to a pole-climber's leg iron on the painter's foot. The loose end of the fall passes through these grips. When he wishes to hoist himself a little, the upper grip holds him while he loosens the bottom one and raises his foot. Then the bottom one is tightened in the raised position, and by loosening the top one and standing up the seat is raised.

Although this takes some time to describe, it takes very little time to operate, and certainly works nicely.

The swing seat attached to the single block is fitted with a couple of guide pieces of 1x4-inch wooden strips, as shown at *A* in the accompanying figure. This prevents the seat from hanging too close to the stack, and also eliminates the trouble of turning around as mentioned in the article just referred to. A hook in the bottom of the seat carries a six- or eight-gallon pail containing the paint.

Having attached his handline to the pipe rod, the painter ties the other end to the swing seat so that when he has painted up to the guy-wire band, he can pull the rod up and transfer the double block again to either the top of the stack or the next guy-wire band, as the case may be. Of course, while making the change, he has the swing seat secured to the stack by means of a spare hook.

In painting, he uses a long-handled hoe brush similar to the one described and shown by Mr. Hawkins; and by reaching to both right and left, one-half of the stack circumference can be painted from one side unless the stack is larger than the average size. As soon as all of the surface within reach is painted, the brush is stuck in the pail, and the painter simply hoists himself 4 to 6 feet and gets busy again.

When the top of the stack is reached, one-half of the painting is done. By means of the spare hook he shifts himself and tackle around the rim of the stack to the opposite side, and then paints his way in easy stages down to the point where he changed his tackle support on the way up. Then, as before, he changes the double block by the use of the pipe rod which he left tied at this point of the ascent.

When the bottom is reached and the tackle unhooked, the stack is finished. The usual time taken on a stack, say 4 feet in diameter and 80 to 100 feet high, is about 2½ or 3 hours. This time includes getting the outfit up on the roof, etc., and getting the tackle in position.

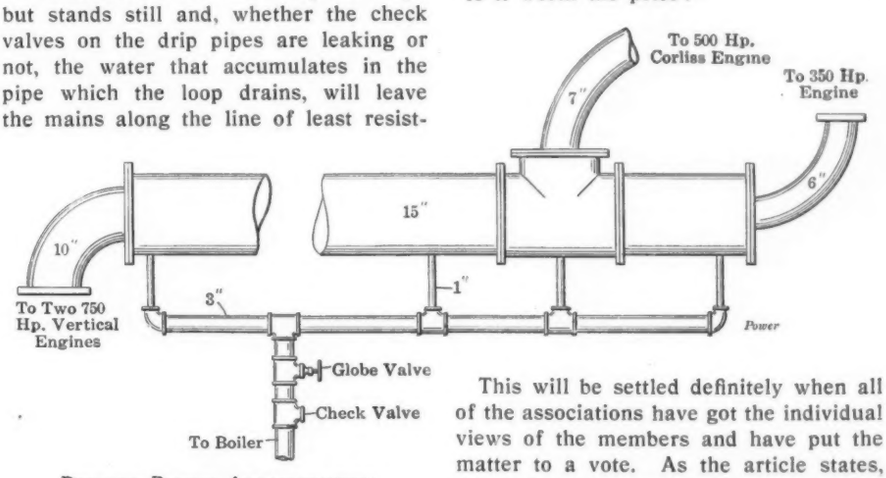
J. A. CARRUTHERS.

Bankhead, Alberta, Can.

Trouble with a Gravity Loop

In the August 30 issue of POWER, Thomas Sheehan describes his trouble with a gravity loop. I wonder if he realizes that the cause he gives for the trouble, namely, leaking check valves in the drips from the steam main allowing the engines to pull the water of condensation back out of the receiver when the engines were carrying an overload, is an impossible one?

There are two ways in which this trouble could occur. First, the loop could be balanced. When this occurs the water of condensation does not "loop the loop" but stands still and, whether the check valves on the drip pipes are leaking or not, the water that accumulates in the pipe which the loop drains, will leave the mains along the line of least resistance as it condenses, and do no harm if not trapped in some pocket. And let me say right here that Mr. Sheehan's steam main is well adapted to hold the water back until the slugs get large enough to wreck an engine or two.



REVISED PIPING ARRANGEMENT

Second, Mr. Sheehan's steam main is not large enough for a plant of 2350 horsepower and, as peak load means overload, conditions get worse, and with overloaded engines on one side and boilers working up to their capacity, or a little above, on the other, one can very well see a good excuse for the gravity loop being overloaded by the boilers priming. And conditions could be still further complicated by losing the vacuum on one of the engines or by the steam pressure dropping.

Does Mr. Sheehan know that if he took the pressure out of his system, connected a good pump on at *A* (see Mr. Sheehan's sketch), filled his receiver full of water until it touched the check valves, then removed the check from the valve and started the pump, he could not pull the water out of his receiver?

Here is a suggestion for Mr. Sheehan. Put up a good 15-inch steam drum in place of the pipe of many sizes. Separate the 10- and the 7-inch engine pipes by connecting the 10-inch at the end of the drum, as per the accompanying figure. Drain the drum, not by a steam loop but directly into his boilers at the opposite end from where the steam leaves the boilers. He does not have to extend the drip down inside the boiler to the water. Then the main will be well drained and the steam loop will not be overloaded. Whether he can save the power of an engine with this arrangement I cannot say.

GILBERT GUERIN.

Adams, Mass.

National Conventions

In the issue of September 27 is an editorial headed "The Rochester Convention," and ending with the words, "Is it worth the price?"

This will be settled definitely when all of the associations have got the individual views of the members and have put the matter to a vote. As the article states, the national convention is a costly affair for the associations as the *per capita* tax levied draws money from some who can ill afford to pay. The tax could be used to better advantage by buying books which are slightly beyond the reach of many engineers and the educational benefit derived from these would be 100 per cent. greater than that of listening to a delegate's report of the convention, which usually consists of an account of the addresses of welcome, winding up with a statement of who were elected as officers. This may be highly entertaining but it is not one whit educational. The only educational benefit which the delegate gets is at the various booths by looking at the exhibits. And the only educational advantage which the members of an association get is the literature which the delegate brings back with him. The delegate, nine times out of ten, is

unable to recall how some little thing or other works, when asked. Decidedly, an annual national convention is not worth the price.

Would it not be better for the various exhibitors to get together and give demonstrations in the different towns? They could send out circulars stating that there would be a demonstration (naming the various articles) on such a day and that it would be of benefit if the recipients or their representatives witnessed the demonstration. The exhibition could also be given in the evening when the engineer could attend, thereby giving greater publicity to the products.

Speaking individually, the national convention, held annually, is not a good thing. Once every three years is sufficient. The officers should be men capable of performing their duties for that length of time.

On the other hand, I think that the annual State convention is a good thing. The expense is not so great and the conventions are generally held at some large-sized city and the country associations' delegates are there able to discuss matters of mutual local interest and see some of the plants and become acquainted with the engineers who are in charge. Then, on his arrival home, a delegate is able to tell the members of his association about things that he saw that were of benefit.

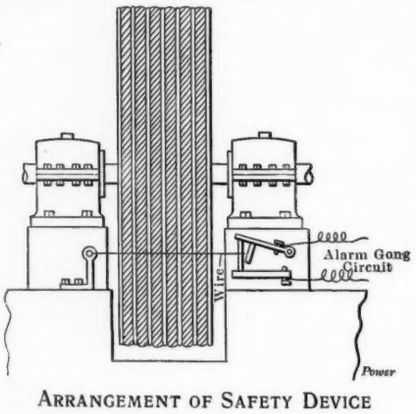
Again, the national convention is not able to recommend the passage of any law to individual States, while such recommendations can be made by a State convention.

GEORGE H. HANDLEY.

Newburgh, N. Y.

Safety Device for Rope Drive

In the September 6 issue, Edward Moran described the details and gave a sketch of a safety device for rope transmission. His scheme is good, although I



ARRANGEMENT OF SAFETY DEVICE

believe that the one which I have is simpler and just as effective.

The accompanying figure shows my arrangement. A wire is stretched across the face of the pulley. At one end it is attached to a fixed post and at the other to a piece of wood which is wedged between the contact blocks of an alarm-bell circuit. When a strand breaks, it hits the wire which results in the wood piece being pulled out of the grip of contact blocks. The upper block then falls onto the lower one, the circuit is closed and the alarm sounds.

E. A. HEINY.

Springfield, Ill.

Engineers' Wages

In the September 13 issue, C. R. McGahey states, "Wages count for nothing." This statement is obviously untrue.

Again, Mr. McGahey states, "Some men are short-sighted enough to say, let us have a union." He then suggests, "An honest board of examiners, which cannot be bought, to find out what a so called engineer does know; find out if he is a $4 man or a $2 man and classify him." Is this not a form of union? Is it not asking the State to enter into a union with you to protect you from your less efficient fellow craftsman? Does it not show a desire to be legislated into a position free from strife, or where strife is reduced to the minimum; where you can rest serene in the knowledge that you are protected and that you need not endanger your own precious being? Does it not show a desire to get the better wage by holding down your fellow craftsman, rather than by the more natural way of lifting him up?

G. H. Kimball, in the September 20 issue says, "In any plant running 24 hours, the matter to be disposed of is only the question of the length of the watches." If you decide on the length of the watches and pay no wages you will find your agreement as to the length of watches will not last long. It is hard to understand how a man is so lacking in self-interest as to make such a statement.

Mr. Kimball again says: "Many men (employers) think that because an engineer does not ask for more pay he does not want it. If they knew how some men feel about this they would realize that a raise gained by asking is considered as given grudgingly." For the purpose of this discussion it is useless to refer to, or have in mind, special cases. In general then, I will state that a raise is always given grudgingly, whether it is asked for or not. The reason the employer pays what he does is because he is not sure that the employee would work for less. If he knew he could reduce his pay roll $50 or $1000 by cutting Tom, Dick and Harry, or by making a general reduction without demoralizing his force, he would do it at once; and this, regardless of the education or efficiency of the employees. This he would do because he is human and an employee would do the same for the same reasons if positions were reversed.

T. M. Sterling, in the September 6 issue, says, "It must be admitted that the wage question is about the first, middle and the last consideration, even though all the other items pertaining to the deal are satisfactory." In this statement Mr. Sterling is absolutely right. He knows what he is working for. If he has a family, he knows he is working for wages to enable him to provide for it. He does not feel that he should apologize to his employer for collecting his wages.

Mr. Sterling then suggests a union for education by means of which the members could be given a rating. We seem to be afflicted with a desire to educate, in proportion to our desire to eliminate ourselves from the wage question. Have we not the best schools and colleges in the world? Our technical schools are the equal of any. If we cannot attend these, we have the best correspondence schools, giving good practical courses. We can secure special books written on any subject in which we may be interested. We have technical papers by the score to enlighten us on modern practice.

We should realize that we are not in the educational field as educators; that is the province of people who are specially trained for the work and who devote their whole time to it. We should not have a morbid desire to cram our education into unwilling subjects. This educational "bug" is too evident with us.

Another quotation from Mr. McGahey, "Consider some of the National Association of Stationary Engineers' meetings; lots of good can come from these, but often one gets the floor who knows less than anyone and the posted man goes away in disgust." This intellectual monstrosity, this self-assumed fountain of knowledge, "the posted man," is anywhere and everywhere that men come together for discussion. He is common to every calling. He makes the most noise in his effort to gain the spotlight and when he succeeds in making himself thoroughly obnoxious, he goes his way bemoaning the stupid ignorance of the rabble. His is not a desire to educate. The applause for him. He is a pest.

This repeatedly expressed desire to be classified, rated or graded is advocated by those who assume that they would automatically become members of class A on the law or rule being adopted; and that the great majority would be relegated to the rear, or degraded and that class A would then be in a position to profit, since competition would be removed. This is the motive. It is useless to deny it.

That you may be disillusioned I ask you to investigate the conditions that obtain in those States where engineers are classified by license laws. There you will find the members of class A as well as B and C working for a lower average wage than the engineers who are not classified.

Through this whole discussion there is

evidence of a hope to attain the ideal. There is everywhere the cry to classify, grade and to eliminate the inefficient, the beer-guzzling, the "bums" and "grafters."

It is very good to have a high ideal, very good to have a subconscious reverie or day dream. It leads man to a purer state. Through evolution he is approaching his ideal; but he is so many centuries in the rear that the practical man is dealing with conditions as they are and trusting to nature and evolution to lay in the lap of posterity the subject of his dreams.

In dealing, then, with conditions as they are and for results during your lifetime, you will grant that it is hopeless to spend time trying to eliminate the inefficient, the beer-guzzling (or the idealist). They are factors in steam engineering as well as in the law, the ministry and every other line of human endeavor.

H. F. Heyrodt expresses my sentiments in the last paragraph of his article in the October 4 issue.

J. J. NASH.

New Haven, Conn.

Do It Right or Quit

In the issue of September 20, there is an editorial under the above title. The title itself is a worthy motto for every engineer. But, unforunately, how few follow such a motto? Yet the engineer is the one who should do things right at all times.

I find that it is just as easy to do a thing right as to do it only half right, and I have always held that anything which is worth doing at all, is worth doing well. Nobody takes pride in what he does unless he is positive that he has done his best.

It has already been said that life's necessities are very easy to get in this country as compared to the older countries of the world. This means that a man in England has to hustle more for what he gets than a man in this country. And, no doubt, this has something to do with this matter of doing things half way.

A job half done would have been better left undone; because it will surely have to be done over again. And it nearly always happens that the job will give way when there is the least time for repair. How much time and labor would have been saved if the work had been well done at first? It is the faculty of nearly all Americans to take things easy. What if something does break down? A fellow has got to work in either case, so what is the difference?

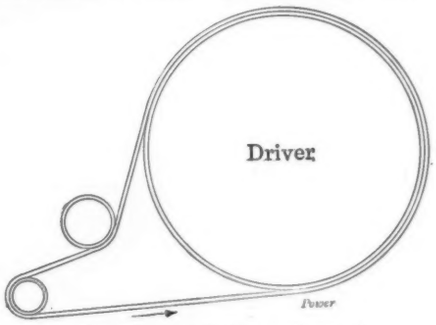
Let us follow the motto of the editorial alluded to, and we will become much better engineers.

J. E. POCHÈ.

Plaquemine, La.

Useful Belt Drives

In the September 13 issue of POWER are shown sketches of belt drives that are said to be useful. Their usefulness is not apparent, although I would not, for that reason, say that they are not useful. The friction load must be considerably increased by their use, although there



AN EFFICIENT BELT DRIVE

may be advantages that will overbalance the loss. The drive illustrated herewith has proved its right to be called useful, as by its use we have been able to save over 1500 pounds of coal per day on a daily consumption of six tons.

The driver is 12 feet in diameter and the distance between the centers is about 10 feet.

R. MCLAREN.

Berlin, Ont.

License Laws

The subject of engineers' license laws has been discussed for many years and from about every angle conceivable. In the issue for September 27, Mr. Nigh gives his opinion of such laws in a manner that would not tend toward the passage of such laws by any legislative body, if his views were accepted.

He acknowledges that if the law tends toward public safety and the making of more competent engineers, the sponsors are public-spirited citizens. As a properly constructed law does tend to safeguard the public and does force the engineer to better equip himself in knowledge pertaining to steam engineering, it would seem that the writer has acknowledged the benefit of such a law. As to the wisdom of forcing the applicant for a license to pay a certain fee, there is a question. It can be only considered when it is the belief that the law is solely for the benefit of the engineer. If it was of no benefit to the engineer and was simply for the welfare of the public the engineer would not stand for it, without a vigorous protest. As engineers have been benefited where suitable laws are in effect, they do not find it a hardship to pay the usual small fee demanded.

If no one would accept the position of an engineer, unless he had been trained for the place, and if, no employer would employ an engineer until he had found out his qualifications other than the price he would work for, there might be an excuse for saying an engineers' license law is not a necessity. As the majority of us know that the above is not the case, then it seems to me that laws are a necessity to compel public safety.

No engineers' license law is complete unless it carries with it a clause governing the construction and operation of steam boilers. This particular feature is of the utmost importance to engineers, as they should be the ones most interested in the safety of their boilers. Admitting the ability of an engineer to determine the safety of the boilers under his charge, we must remember that the owner is the one who must pay for repairs and new installations. When he refuses to consider what his engineer may have to say in relation to his plant, is it not wise legislation that compels him to make proper repairs, or renew unsuitable boilers?

Where the owner is willing to take the advice of his engineer and is willing to purchase the best that the boilermaker can produce, it may not be necessary to compel him to comply with a law. However, as such conditions are not too frequent, the engineer, for his own as well as the public's safety, should labor for suitable laws governing the construction and operation of steam boilers.

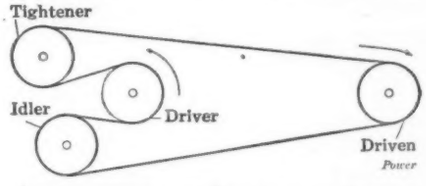
All laws are the outcome of the failure of man to consider his fellow man. If the golden rule was actually carried out by all, the majority of our laws would be of little use. Unfortunately greed is the gravest fault of civilization and the desire of employers to get all they can causes many of them to purchase the cheapest, whether it be steam boilers or the labor to operate them.

T. N. KELSEY.

Lowell, Mass.

Trouble with the Belt

I would suggest to Mr. Hamill, who inquires for a solution of his belt trouble in the September 27 issue, that he run



ARRANGEMENT OF PULLEYS TO SECURE REVERSE MOTION

the belt straight instead of crossing it. In order to get a reverse motion it will be necessary to arrange the drive as shown in the accompanying figure. If his pulleys are in line, he will have no further trouble due to the belt running off. With the arrangement shown herewith, the belt should last twice as long as it would with the other layout.

S. MCRAE.

Fulton, Ala.

Progress in Flue Gas Analysis*

By G. H. Kelsay

In the past year the progress made in flue gas analysis has not been as rapid as might be expected. The committee's report is presented in abstract together with the discussion at the meeting and written discussion sent to Power.

As this is the third year this subject has been before the committee, it has been of interest to watch the progress made by gas analysis in boiler-room practice.

Like all other methods that promise to be beneficial in developing higher economies, gas analysis and the automatic recording analyzer were taken up and heralded by many engineers as promising in a way to revolutionize boiler-room economics, all of which has been exceedingly beneficial, as it has been the means of gradually developing among operating engineers an understanding of furnace conditions and some of the most fundamental principles in economical coal consumption.

Inquiries were sent out to all known users of gas analyzers and automatic recorders to obtain as near as possible just what development has been made during the past year on this subject. In addition to inquiries, personal letters were directed to those whom it was thought had done the most during the past year along the line of experimental work, with the idea to determine as nearly as possible what progress has been made.

Replies were rather disappointing in that very few new ideas or expressions were received, which indicated that flue-gas analysis has not made such radical strides as might be expected.

As was shown in previous reports of this committee, there still seems to be considerable trouble in getting successful operation from recording apparatus, as most all the recorders now in the hands of operating engineers seem to give considerable trouble and lack a degree of accuracy, such as to discourage interest by the operating engineer and the boiler-room force. This may be due partially to a lack of diligence on the part of operating engineers and probably this objection is gradually being overcome.

There are different opinions among operating engineers as to the importance of continuous records and intermittent records. Some believe in occasional analysis of the flue gases by means of the Orsat analyzer, so as to establish the conditions that give best economy, and then endeavor to keep the firing up to these conditions. Others believe that continuous and recorded analysis of the gases is necessary for best results.

Two methods of obtaining continuous analysis are used. One is the use of the sampling bottle which collects the average gas for a day's run, and the other is by means of the automatic recorder which intermittently or constantly records the CO_2 at the time the gas is being made at the furnace. There has been some very good evidence presented against the sampling vessel, in that it does not indicate to the engineer the time in which he is getting good or poor results in his furnace. It only gives the average for the day and the fireman is unable to judge at what times he is getting best results, whereas he can watch the continuous recorder and determine what condition gives the highest per cent. of CO_2 in his gases. In power stations where the load is a fluctuating one some seem to have difficulty in obtaining good CO_2 records.

It has been the opinion of some that the percentage of CO_2 could be taken as practically a direct indication of boiler efficiency. That is, a high percentage of CO_2 always meant a high equivalent of evaporation, and low percentage of CO_2 meant a low equivalent of evaporation. However, it has been proved quite essential to occasionally analyze the gases for CO, so as to guard against the likelihood of excess CO, as it has been quite conclusively demonstrated that the highest percentage of CO_2 does not mean the highest boiler efficiency and that a very high percentage of CO_2 may be obtained with very low boiler efficiency or a very low equivalent of evaporation. This may be on account of throttling the air supply on the furnace to such a very low point that there is not sufficient to burn the coal, thereby producing such a high percentage of CO in the flue gases as to reduce the equivalent of evaporation, and at the same time give a very high percentage of CO_2.

Gas analysis as applied to boiler-room practice will, no doubt, gradually adjust itself into methods that will be very beneficial in developing and maintaining higher boiler economies, but it is possible that many overdrawn ideas have been entertained by many engineers as to its value. Also many engineers have failed to give the subject the attention that it deserves and would probably find more merit in the analysis of flue gases than they now think.

It is the practice with a few operating engineers to pay firemen a fixed sum with a bonus of variable amounts, depending on the per cent. of CO_2 obtained from their respective boilers while they are on duty. The following is a sample of what one company is doing in this respect:

When products of combustion show CO_2—

	Extra per Day. Cents.
15 per cent. for 10 hours.....	30
14 per cent. for 10 hours.....	25
13 per cent. for 10 hours.....	20
12 per cent. for 10 hours.....	15
11 per cent. for 10 hours.....	11
10 per cent. for 10 hours.....	10
9 per cent. for 10 hours.....	9
8 per cent. for 10 hours.....	8
7 per cent. for 10 hours.....	5
6 per cent. for 10 hours.....	0

It is the argument of the engineer that the extra amount paid the fireman is a small percentage of the amount the fireman is saving the company through his efforts to obtain the increase in his wages. This method is not generally practised by operating engineers, and it appears to be somewhat doubtful as to whether a bonus should be paid firemen on the basis of CO_2 when there are other important elements entering into the proposition. Particularly so when extremely high CO_2 fails to necessarily indicate the most economical furnace operation and when it may be possible for a fireman to obtain very high percentage of CO_2 with very low equivalent of evaporation, because it may be possible for him to obtain these results by throttling the air supply on the boiler to such an extent as to make the work of the boiler very light and his work very light. Thus he might be obtaining the highest percentage for doing the least amount of work and obtaining the poorest efficiency in his furnaces.

Discussion

H. G. Stott, vice-chairman of the committee, presented the report, which in addition to the material upon flue-gas analysis here given, and that upon forced draft in our issue of October 25, treated of Low-Pressure Turbines, Steam Meters and Peak Loads. The other subjects will be presented later. The paper was unfortunate in coming before the meeting just previous to adjournment, compelling the continuation of its discussion until the next morning, when its encroachment on the business assigned for that session impelled the chairman to cut the discussion off long before the subject was exhausted and while there were several with good things yet to say. We shall be glad to offer in the columns of Power an opportunity for the continuance of the discussion and present in this number discussion which has been sent to this office for that purpose.

Mr. Stott remarked in his presentation that "With bituminous coal and forced

*Portion of the report of the Committee on Power Generation of the American Street and Interurban Railway Engineering Association, Atlantic City, October 10-14.

draft there is no difficulty in getting 225 per cent. rating with furnaces as ordinarily built. Better evaporations have been obtained with forced draft than with natural draft. The explanation seems to be that with forced draft the combustion takes place on the surface of the coal. The flames are shorter and do not shoot up into the tubes and become extinguished. In other words, the combustion is complete before the gas has reached the chilling surface. With natural draft the pressure inside the setting is less than that of the atmosphere and the infiltration of air is a very serious matter."

B. F. Wood, of the Pennsylvania Railroad, said that boilers were capable of doing much more than was now expected of them, and a suggestion of the possibilities might be taken from locomotives burning from 100 to 150 pounds of coal per square foot of grate area per hour. Some form of stoker that would effect rapid firing was essential for stationary boilers.

G. H. Kelsay, the author of the paper, said he did not wish to convey the impression that he recommended paying the fireman on the basis of CO_2 in the flue gas, although he knew of some plants that paid a bonus on the CO_2 record.

A member whose name was not announced said that he had looked very carefully into the subject of CO_2 analysis and had visited a number of plants where CO_2 recorders had been installed, invariably finding them out of working condition.

Charles Hewitt, of Philadelphia, invited the last speaker to visit his plant where he had two flue-gas analyzers in almost continuous operation for three years and now giving very satisfactory service.

C. O. Mailloux said that the days of tall chimneys were fast passing away. The proper way to supply air to a boiler was by a combination of suction and pressure. He had built, not the tallest, but the longest chimney in existence, a tunnel over 2000 feet long, having been driven to convey the gases to a point where the 100-foot vertical stack would be inoffensive. He brought out strikingly the fact that the change of temperature between the furnace gases and the boiler-heating surface takes place within an infinitesimal surface, less than one-thousandth of an inch, in which there is a fall of temperature of some 1500 degrees. The problem of handling forced-draft systems efficiently in railway-power service comes back to getting firemen to fire well at the varying rates which are required by the varying loads. It is much easier just to meet the demand for steam when the load is steady than when it varies widely, and that is one reason why the CO_2 recorder is more valuable in the station carrying a lighting load than in a railway station. In the effort to maintain a constant steam pressure the usual practice is to open the damper when the pressure begins to fall and put on more coal. Very often this results in holes in the fire which reduce the efficiency and do not increase the output. If the pressure gets too high, the first thing which is done is to close the damper, which gives an insufficient supply of air and the hot coal in the furnace goes on producing CO. Under practical operating conditions the percentage of CO_2 is far from being a true index of boiler efficiency, taken without due consideration of other factors; but efficiency after all is a secondary consideration in boiler operations, subordinate always to continuity of service. Improper control of the damper is responsible for more loss of efficiency than any other detail of operation of boilers. Automatic damper-controlled devices are not satisfactory. The best method is to have a system of signals connecting the boiler room with the switchboard, so that the firemen can control the dampers under instructions from the switchboard operator who sees the load fluctuations. The boiler room is entitled to receive as much attention in this respect as the engine room. In the boiler room, 90 per cent. of the energy is converted, and any percentage of saving which can be effected in that conversion is much more important than the same percentage of saving upon the 10 per cent. conversion which takes place in the engine room. Damper control should not be regulated solely with reference to the CO_2 in the flue gases. The first thing which the damper should control is the steam pressure, and the second essential in their manipulation is to control the volume of steam produced in the boiler. Because a satisfactory steam-flue meter has not yet been developed, it is practically impossible to determine accurately the amount of steam which a boiler is making. The quantity of feed water is not an adequate index, because of a number of boilers fed with the same weighed or metered feed water one may be doing much more than the others. Mr. Stott had told him of instances in which two boilers of 1500 horsepower each had been found to be operating at very different rates of production, one giving 500 horsepower and the other 2000.

The discussion was closed by William Roberts, of Akron, O., who said that progress was being made in the development of reliable and accurate flue-gas analyzers, and spoke reassuringly and hopefully of their usefulness in connection with steam-boiler plants.

Discussion Sent in to Power

Lewis Sanders, vice-president of the Sarco Fuel Saving and Engineering Company, contributes the following written discussion:

We are quite in agreement with Mr. Roehl's statement* regarding the high hopes originally raised by automatic CO_2 recorders and the failure to realize on these hopes. These hopes were based on a great deal of erroneous and misleading statement made on the subject of recorders and the control of furnace operations by means of CO_2 records. One of the prime causes in failing to realize anticipations was the fact that very little stress was laid on the amount of care and attention necessary to maintain high boiler-room efficiency by means of CO_2 control. Consequently, recorders were frequently installed without provision being made for following up their records and enforcing efficiency on the part of the firemen. It was evidently expected that a plant could be operated with less attention by the use of a CO_2 recorder than without, and when this was found not to be the case, the use of the instrument was often condemned. The case is, in fact, exactly the opposite; it takes more attention to run a plant with the aid of a CO_2 recorder than without, and the results repay the effort. It also takes more brains and supervision to operate a compound-condensing engine than a simple slide-valve engine. It should be borne in mind that running a CO_2 recorder and getting records does not constitute using it.

Mr. Roehl's point regarding the decrease in thermal-transmitting ability of the heating surfaces with decrease of gas velocity over it, does not take in all the factors involved in the efficiency obtained with high CO_2. There is another factor and that is the temperature, which rises with high CO_2 and, therefore, increases the heat-absorbing capacity of the surfaces, probably considerably more than it is decreased by the lowering of the velocity of the gases. The loss of efficiency with excessively high CO_2 is not, therefore, explained by decrease of gas velocity.

The entire explanation of the falling off in economy with high CO_2 is covered in Mr. Roehl's second point; that is, the formation of CO. The point at which CO will form varies with different coals and furnaces. We always advise that with hand-fired furnaces and Eastern coal, running as high as 20 per cent. volatile matter, no higher than 13 per cent. CO_2 be carried, and the furnaces be tested once a month with an Orsat apparatus in order to determine if any deterioration in the baffling is resulting in incomplete combustion and formation of CO. With stokers the CO_2 may with advantage be pushed a little higher and with oil and gas fuels may be pushed up as high as 15 to 16 per cent., but we always urge a careful checking with the Orsat apparatus to detect CO when such high percentages of CO_2 are carried. This is particularly necessary under oil-fired

*October 25 number of Power, page 1913.

boilers where a breaking down of the checker work would cause the production of CO under these conditions.

It was known long before the Geological Survey began its work that the most economical air supply to operate with in well constructed hand-fired furnaces was about 40 per cent. in excess of the theoretical, and that this was indicated by from 12 to 13 per cent. CO_2 with Eastern coals. Apparently, all this old knowledge was lost sight of in the over-enthusiastic literature issued by the makers of CO_2 recorders and no limit at all was placed on the percentage of CO_2 that it was desirable to obtain. A very clear distinction should be made between the efficiency due to design of apparatus, efficiency due to state in which it is kept and efficiency due to method of operation. It is due to the failure to separate these that much of the very noticeable confusion of ideas on boiler operation is due. With defects of design the operating man has little to do; he generally has to make the best of what he has. The most common defect is probably faulty furnace design which tends to produce considerable CO. Defects of condition in the furnace are poor condition of the baffling and air leaks. These result in the formation of CO and in high stack temperature. In the boiler they consist of dirty fire surfaces and scale, shown by high stack temperature. Such points should be investigated at intervals, say once a month, as conditions change slowly. Although we make recording pyrometers, we do not advise their use on boiler plants, as we consider a mercury thermometer all sufficient to take stack temperatures. Defects of operation comprise faulty firing of coal and adjustment of draft and here conditions change continuously and we therefore need a CO_2 recorder as a guide.

Operated with intelligence and with due regard to the engineering facts in the case, the CO_2 recorder is by all means the most reliable operating guide for firing the furnace.

Embury McLean, president of the Engineer Company, submits the following written discussion:

Mr. Roehl claims that the use of CO_2 recorders has not resulted in the improvement in boiler and furnace efficiency expected. Two reasons are given for this unsatisfactory result:

First, that as the percentage of CO_2 increases (or as the excess air is diminished) the velocity of the gases through the boiler is reduced, and consequently the efficiency of transmission of the heat units from the gas to the boiler is reduced.

Second, that the means employed to obtain high CO_2 usually result in the presence of CO, which more than offsets all the advantage gained from the high CO_2.

It is true that the efficiency of the transmission of heat from the gases to the boiler increases with the velocity of the gases, when the amount of heat absorbed by a unit of surface in a given time is the only element considered. On the other hand, when the total number of heat units contained in the gases passing a given surface is considered, the slower the velocity of the gases passing the surface, the greater the proportion of the heat units transmitted.

The loss incurred in attaining an increase in velocity of the gases by dilution far outweighs any gain thereby. Assuming a fixed rate of combustion, if the velocity be increased by increasing the volume of gas by dilution with excess air, the efficiency is very materially reduced, for the temperature of the furnace varies directly with the percentage of CO_2, or inversely with the percentage of excess air, and the rate of absorption of heat depends upon the difference in temperature between the gases and the boiler. Again, still assuming a fixed rate of combustion, the velocity of travel of the gases can be increased by lengthening the path of their travel by increasing the number of baffles.

By applying the laws enunciated by the United States Geological Survey, the increase in the number of baffles will increase the resistance and, consequently, the "pressure drop" between the grate and the chimney, leaving a proportionately smaller "pressure drop" available for the grate. This, of course, would reduce the output of the boiler.

Should we resort to mechanical draft to maintain the output of the boiler, we find that the weight of gas passing through the boiler varies as the square root of the "pressure drop," consequently, the increase in "pressure drop," due to the increase in baffling, will enormously increase the power required to operate the fan. Of course, under these conditions, an increase in output from the boilers would be inexpedient, as it would be attended by abnormal cost of operation of the fan.

It is true that the presence of high CO_2 does not necessarily mean high furnace efficiency, because if accompanied by CO a great loss is sustained, due to incomplete combustion. Therefore, any manipulation of the furnace which will tend to produce CO, is undesirable. Mr. Roehl, however, refers to the balanced-draft system and states that it unquestionably gives a very high CO_2 result, and that the claims of the sponsers of the balanced-draft system are not exaggerated in this respect.

The balanced-draft system differs from other means of obtaining high CO_2 in the furnace (by skilful manipulation, etc.), in that it is impossible, from the very nature of the system of regulation, to produce CO in any appreciable quantity. The fact that in the wide use of this system in the United States and Europe results obtained universally show a material increase in the percentage of CO_2, with practically no CO, substantiates this statement. This result is accomplished in a very simple way by the use of the very simplest apparatus, entirely practical for boiler-room use.

The control of the furnace in accordance with the percentage of CO_2 in the flue gases depends upon the fact that the temperature of the furnace for a given rate of combustion increases directly with the percentage of CO_2 in the flue gases. Again, for a given rate of combustion the rate of absorption of heat by the boiler, and consequently the steam pressure of the boiler, depends upon the initial temperature of the furnace gases.

If we can accurately and automatically control the supply of air to the furnace by the steam pressure of the boiler, it is evident that a rate of supply can be maintained which will give a maximum percentage of CO_2 in the flue gas. It has been found impractical to accurately control the air supply to the furnace where the air is drawn through the bed of fuel, which of necessity means a pressure less than atmospheric above the grate and in the combustion chamber. Under these conditions, air is drawn into the furnace chamber through the fire door when open, through cracks and crevices, and through porous brickwork.

The air supplied to the furnace by a chimney varies with the thickness of the fuel bed, which is constantly changing, with atmospheric conditions, and with the opening of the fire door and other leakages above the grate. In order to obtain accurate control of the air supply, it is necessary to have some more reliable source. For this purpose, we resort to the fan blower, and with the balanced-draft system a special type of blower is used, which delivers, for a given speed, a constant volume at a variable pressure.

As the combined result of two variables cannot readily be controlled, it is necessary to eliminate one of the variables. For this reason the draft is balanced, which means that atmospheric pressure is automatically maintained in the furnace chamber at the fire door for all rates of combustion. Under these conditions all excess suction of the chimney beyond that required to remove the gases from the boiler is eliminated; the function of the chimney now being merely to remove the gases from the boiler and not to supply air to the furnace.

If the special type of blower is operated by an engine, the speed of which is controlled by an automatic valve which follows the steam very closely and varies the speed of the blower inversely in proportion to the pressure of the boiler, giving extreme speeds on a variation of, say two pounds, and intermediate speeds proportional to the variation between

these extremes, the air supply to the furnace will at all times be limited to the amount necessary to maintain the maximum temperature in the furnace, which, as we have stated, corresponds with the maximum percentage of CO_2 in the flue gas.

The only condition imposed to maintain the maximum percentage of CO_2 is that a sufficient supply of fuel, evenly distributed over the grate, be maintained. The balanced-draft system accomplishes the rest automatically. Even if this condition is not perfectly maintained, the loss due to thin spots in the fire is less with this system than under ordinary conditions.

The operation is as follows: Assume the steam pressure a little above normal, the rate of combustion is reduced to a point slightly below that required to maintain steam pressure and for a moment there is a deficient supply of air. The temperature of the furnace drops and the steam pressure begins to lower.

As this happens, the speed of the blower gradually increases until the theoretical rate of air supply has been attained. At this point the maximum furnace temperature is attained which means an increase in steam pressure and a repetition of the same process, which will continue to control the air supply to practically the theoretical amount necessary to maintain the rate of combustion so long as the steam pressure remains within the limits of the adjustment of the valve.

If the steam pressure varies more than this amount, due, for instance, to sudden increase of load on the boiler, or to neglect to keep an even supply of fuel on the fire, the blower will run at its maximum speed supplying an excess of air, but increasing the rate of combustion to a point, where, notwithstanding the excess of air, sufficient heat units are developed to bring the steam pressure back to within the limits of the valve, when the air supply is again reduced to practically the theoretical amount required, and vibrates a little above and a little below this amount, so long as the boiler pressure remains within the limits of the valve.

Under these conditions, it is impossible to obtain any appreciable quantity of CO, as the change in temperature due to the presence of CO will immediately be accompanied by a reduction in temperature which will in turn increase the supply of air until the theoretical rate is attained.

We see, therefore, that balanced draft or the maintenance of atmospheric pressure in the furnace chamber, does not in itself control the air supply to the furnace, but it is an essential element in accomplishing that result, as no amount of refinement of regulation of either the blower or of the chimney can accurately control the air supply as long as the chimney remains a variable factor. The balanced-draft regulator is adjusting the air supply constantly and is working every moment of the time, whereas the fireman, having other duties to attend to, at best cannot devote more than 10 per cent. of his time to this regulation.

M. W. Campau, of the Precision Instrument Company, Detroit, Mich., writes:

In making the statement that "high CO_2 with unchanged combustion reduces gas velocity across the heating surface," we think that Mr. Roehl has failed to reduce his high and low CO_2 gas to the same conditions.

Suppose you have a fixed size of opening (represented by the boiler-flue area), through which you are to pass a quantity of gas. To pass in the same length of time, 150 volumes would have to travel at a higher velocity than 100 volumes. Assuming 100 volumes to represent perfect combustion, with just the necessary amount of air, then something more than 100, say 150 volumes, would represent incomplete combustion with excess air. The 100 volumes of gas would be the hottest because the, say, 150 volumes would be cooled down by the amount of heat required to heat the excess air. The gas in perfect combustion would, of course, represent a high percentage of CO_2, and the imperfect combustion, a low percentage of CO_2. This may be expressed as follows:

100 vol. air	Perfect combustion, 100 vol. air burned	100 vol. gas	high CO_2, hot, slow velo'y
150 vol. air	Imperfect combustion, 100 vol. air burned, and 50 not burned	150 vol. gas	lower CO_2, cooler, higher velocity

When coal is completely burned in the presence of air, and the exact amount of air required is used, the CO_2 will form the same volume in the waste gases as does oxygen in the air (nitrogen remaining constant, and omitting the negligible quantities of water, gas, SO_2, etc.) This well known reaction is:

$$79\ N_2 + 21\ O_2 + C = 21\ CO_2 + 79\ N_2.$$

In complete combustion the volume of the gas passing through the furnace, and therefore the velocity, is unchanged. Size of opening remaining fixed, the velocity of the gas is only changed by adding air.

Mr. Roehl infers that when the gas is traveling at a high velocity, the heat in the gas is transmitted to the water better than with the gas at a low velocity. We think this is open to argument, but it is quite easy to imagine that in a stream of gas flowing quietly, there would be, in the core or heart of the stream some particles of gas which would not come in contact with the heating surface, which they might do if they were tumbled about, so to speak, in a rapid current. It is always considered advisable in transferring heat from one moving medium to another in any apparatus, to break up the currents or change their direction so as to bring all the particles of the heating medium in contact with those being heated, or the heating surface, so that all the heat may be extracted, and this idea is carried out in many well known devices.

The object to be gained, whether by "high velocity" or otherwise, is the complete extraction of the heat in the gas, and we believe that this may be better accomplished in a boiler setting by breaking up the current with baffles, than by introducing excess air to increase the velocity.

It cannot be denied that perfect combustion means high CO_2, and high temperature at the furnace, as in the 100 volumes assumed above, and it should be the aim of any furnace operator to get high CO_2, or high furnace efficiency, and then reconstruct his setting so as to get high combined efficiency of furnace and boiler. If this were done as above outlined, there would be no "rise of flue temperature with increased CO_2," which is not the fault of the combustion, but the fault of the boiler.

However, let us suppose that it is more advantageous to an installation to run at a low percentage of CO_2. Then it should be run at that per cent., and it is just as important to the man running it to know what his percentage of CO_2 is, whether it is 1 or 15 per cent. Therefore we submit that he should have a CO_2 recorder in any case, and we think he would not be disappointed with the information gained therefrom.

J. A. Caldwell, of the Caldwell Economy Company, New York City, writes:

Speaking of Government statements, I have sometimes thought they may not be infallible. For instance, from the report made by the Naval Liquid Fuel Board, 1904 (69 tests), you will find a summary on pages 250 to 253 covering different kinds of burners in which the average CO_2 is stated at 7 per cent. or a little over, and the five tests at which the maximum evaporation per pound of oil was secured read 7.24, 7.68, 7.70, 8.53 and 7.86 per cent., the average for the five tests being 7.8 per cent.

This does not begin to compare with the results obtained by the Pacific Light and Power Company (Frank T. Clarke), on fuel-oil tests which averaged about 14 per cent. on Babcock & Wilcox boilers, the gases drawn from the bottom of the second pass, and the equivalent evaporation from and at 212 degrees per pound of fuel being 15.35 pounds. It would seem that the two oils could not vary so much as this in the constituent that would affect the CO_2.

E. A. Uehling, of the Uehling Instrument Company, Passaic, N. J., sent in the following discussion:

There are very good reasons why the reports on the results obtained from the majority of the early purchasers of CO_2

recorders should be disappointing. First, the earlier CO_2 recorders were complicated and, therefore, difficult to keep in running order. Second, these instruments were generally placed in the boiler room without adequate protection against the dirt and dust, which increased the difficulty of keeping them in order. Third, they were frequently left at the mercy of ignorant firemen, or at best given in charge of the engineers, all of whom may have been good practical men no doubt, but most of whom were entirely unfamiliar with that class of apparatus, and only too often prejudiced against all "scientific frills"; not infrequently with minds made up beforehand that the thing was no good, and that it would not work anyhow, and as a matter of course, had little difficulty in proving it. Fourth, they were imported and pushed into many places where both personnel and conditions precluded successful operation, by very efficient salesmen, whose interest in the apparatus sold ceased on receipt of pay, thus leaving the recorders as orphans in a foreign and often unfriendly camp, among surroundings making useful existence impossible.

Under these conditions it is not at all surprising "that the hopes that the CO_2 recorders aroused as to a solution of the problem of guidance in the attainment of high efficiency have not been realized."

The disappointing reports received by the committee prove nothing against the value of CO_2 as a guide to efficient firing. The economy directly derivable from a high per cent. in the flue gas has, no doubt, been exaggerated by over-zealous venders of CO_2 recorders. Of the fact that they have been pushed injudiciously there can be no doubt. That many of the earlier instruments were faulty in design and badly constructed must be admitted; that not one in ten of the CO_2 recorders installed received the intelligent care and attention which a scientific instrument should receive cannot be denied. The great majority of them were foredoomed to failure from the beginning.

Today all this is changing for the better. The practical men are becoming more and more familiar with scientific methods and apparatus.

The CO_2 recorders have been improved and simplified. They are more easily handled and require only a moderate amount of attention. Intelligent attention, the sledge-hammer type, is still ruinous.

To say that the higher the CO_2 the greater must be the economy, is absurd. To contend that CO_2 is no guide to efficient firing is even more absurd. For every kind of fuel and construction of furnace there is a per cent. of CO_2 which gives maximum efficiency. It may be as low as 10 or as high as 16 per cent. This best per cent. of CO_2 must be ascertained by practical economy tests, and having been ascertained, the CO_2 recorder will keep you informed how well or how badly the fireman has performed his duty. It is important that the fireman should be able to see what he is getting all the time. An indicator at or near the boiler front is, therefore, of the greatest value.

The committee report contains the further statement:

"More light is at present available on the cause of the disappointment than was available after the CO_2 recorders had been in sufficiently extensive use to make the disappointment evident. This light is, of course, that concerning the relation between gas velocities and thermal transmitting ability of the heating surface."

This statement is not very clear but it seems to convey the idea that for some time after it had been discovered that CO_2 recorders were of little or no use, no good reason for the disappointment existed; but that at present more light is available and that "this light is, of course, that concerning the relation between gas velocities and thermal-transmitting ability of the heating surfaces."

That CO_2 recorders have been disappointing is freely admitted, and we have shown that their failure to make good was caused partly by inherent imperfections, partly because of misplacement by over-zealous venders, but mostly because they did not get a fair chance. But all this has no vital bearing on the fact that the per cent. of CO_2 in flue gas is the most available and best guide to efficient firing.

The velocity of the gas is, no doubt, an important factor, and it is quite possible that the reduction in gas volume due to a high per cent. of CO_2 may appreciably affect the rate of absorption and thus slightly increase the stack temperature and hence the loss; but no sane combustion engineer would advocate admitting an undue excess of air for the purpose of obtaining a high gas velocity.

If high gas velocity is of real importance, as it seems to be, it must be attained by other means than that of diluting the products of combustion, if the gain due to more efficient absorption is not to be overbalanced by heat carried off by the greater volume of gas necessary to obtain the higher velocity.

The per cent. of CO_2 in flue gas is a true measure of the excess of air passing up the chimney; in connection with an occasional sample from the rear of the combustion chamber it gives the amount of air infiltration, a most prolific source of heat loss. In combination with the stack temperature it gives the loss due to the sensible heat carried off by the gases. The continuous record is a perfect check on the fireman. It shows how often he fired, how well or how badly he did it. It shows when he cleaned his fire and how long it took him.

An instrument that will make such a record should certainly be a valuable adjunct to a boiler and be amply worth what little extra attention it may require. If, in addition to the above, it will indicate on the boiler front in plain view of the fireman, showing all the time the condition of his fire, all reasonable requirements are fulfilled.

One word more regarding the payment of a bonus to firemen for attaining a high per cent. of CO_2. It seems ridiculous to pay a bonus for CO_2 as low as 7 per cent. Under anything like good conditions and fuel, 10 per cent. should be the minimum set for a bonus. Whether 15 per cent. is economically attainable depends on kind of fuel and operating as well as furnace conditions. As already stated, the most economical per cent. of CO_2 should be determined for each plant and then striven for.

High CO_2 is not incompatible with low CO and low CO_2 is no guarantee against the presence of CO. Except in the presence of very high CO_2, i.e., a very small excess of air CO is due to irregular and uneven firing. If the firemen receive a bonus for high CO_2, they should be penalized for high CO, and particularly so, if it occurs in connection with low CO_2. For the same per cent. of CO the fuel loss is twice as great when it occurs with 7 per cent. of CO_2 as with 14 per cent.

The subject of CO_2 and CO_2 recorders is a large one and the more intelligent discussion it calls out the better.

To coat iron with a covering of lead which will be in absolute metallic contact, states the *Chemical Trades Journal*, is a difficult operation. Valves and small fittings made of iron well galvanized on the exterior may be homogeneously covered with lead in the work shop by any mechanic. The method consists in immersing the piece to be coated in water to which a few drops of sulphuric acid have been added. Then, while in the acid water, the piece is readily amalgamated in the usual way by squeezing mercury through close-woven cloth all over its surface and thoroughly rubbing it in. The excess mercury is rubbed off and the piece carefully dried without heat, and then immersed in a bath of lead, which should be well above its melting point, so that it would not tend to solidify by introduction of the cold piece. The casting may be withdrawn after about twenty seconds, and will be found to be homogeneously covered with lead. This method requires the piece to be galvanized before applying the lead, and the galvanizing must be in good condition, otherwise the subsequent amalgamation will be imperfect and present an unsightly appearance.

Seven Killed in Boiler Explosion

By A. D. Blake

A climax water-tube boiler exploded at the works of the American Manufacturing Company in Brooklyn, killing seven persons and injuring many. The primary cause of the explosion was corrosion of the bottom head of the central drum.

On Thursday morning, October 20, there occurred the most disastrous boiler explosion that has been seen in the vicinity of New York for many years. The accident happened at the works of the American Manufacturing Company, in the Greenpoint district of Brooklyn, and resulted in seven deaths, among which

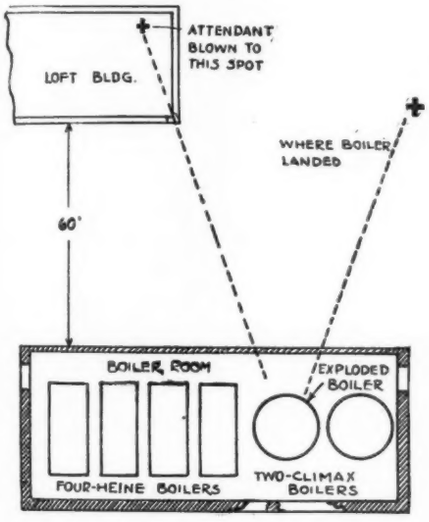


FIG. 1. PLAN OF BOILER ROOM

was that of the chief engineer, and several persons were injured. At the time of the explosion the plant had been running for about three-quarters of an hour and everything was supposed to be operating under normal conditions.

The boiler which exploded was of the Climax water-tube type, operating under 150 pounds steam pressure. In the same boiler room there was another boiler similar to the one which exploded and four Heine boilers. Without any warning the boiler shot straight up through the roof like a skyrocket and landed in a vacant lot about 50 yards distant, the impact being so great upon landing that a hole several feet deep was dug into the earth. Although the whole side of the boiler room was torn out, strange to say, the other boilers were not seriously damaged. It was fortunate that the boiler after being hurled into the air landed as it did in the vacant lot, for if it had turned and fallen in the other direction it would have crashed through the roof of the factory, in which case the loss of life would undoubtedly have been great. An idea of the force of the explosion may be gained from the fact that one of the firemen was hurled through the side of the boiler room, across a 60-foot street, through the side of a wooden building and into a loft where he was found some time afterward. (See Fig. 1).

Fig. 2 is a view of the side of the boiler room, the wall of which was blown out. In this view may be seen the other boilers, the space occupied by the exploded boiler and the hole which was torn in the roof.

Fig. 3 shows the boiler after striking the ground. A curious fact is that the boiler rests partly upon the stack, showing that the latter reached the ground first. It should be noted from this view that the boiler is practically intact, lacking only the bottom head, at which point the rupture occurred; the damage to the tubes was caused by striking the steel roof of the boiler house.

HISTORY OF THE BOILER

The boiler, which was installed in March, 1898, by the Clonbrock Steam Boiler Company, former makers of the Climax type of boiler, was of 600 horsepower capacity and weighed, complete, considerably over 40 tons. A section of this type of boiler is shown in Fig. 4. The central drum was 48 inches in diameter and 29 feet high, it being made up of

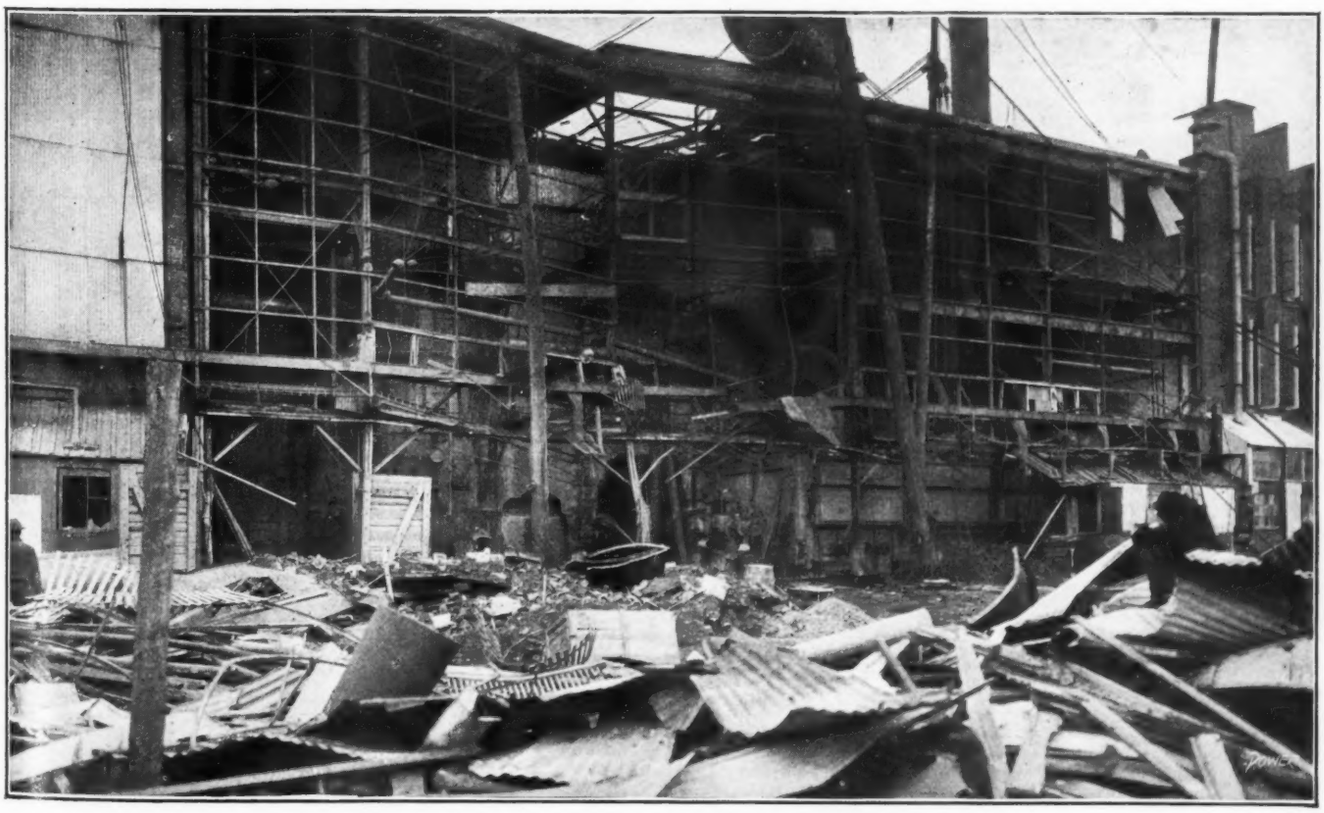


FIG. 2. VIEW SHOWING SIDE OF BOILER ROOM BLOWN OUT

a number of sections the circumferential seams of which were single-riveted lap joints, the longitudinal seams being welded. The heads were bumped to a radius equal to the diameter of the drum and were held to the shell by ⅞-inch rivets. Both shell and heads were of ¾-inch firebox steel having a specified tensile strength of 60,000 pounds per square inch. An enlarged sketch of the bottom head and base is shown in Fig. 5. In the later boilers of this type the heads are convex, as shown in Fig. 6, and are made of ⅞-inch metal.

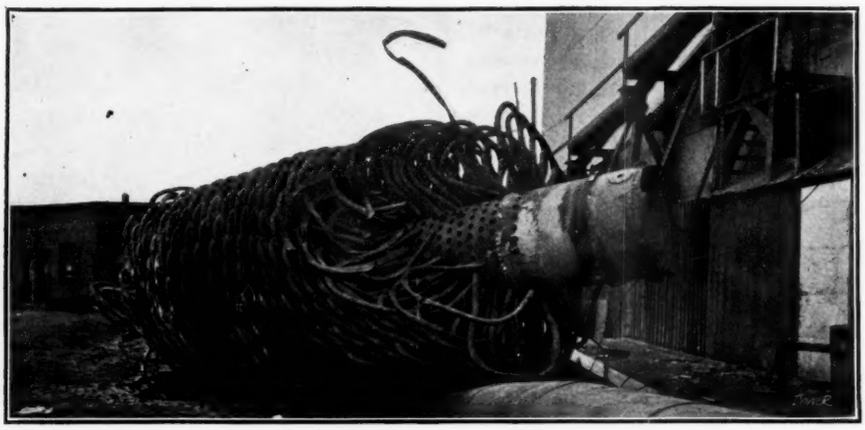


FIG. 3. BOILER AFTER STRIKING THE GROUND

The boiler had been inspected by the Hartford Steam Boiler Inspection and Insurance Company just a year ago and was to have been inspected again within a week of the date of the explosion. In addition to this, the police department had inspected it last December and had subjected it to a hydrostatic test of 225 pounds per square inch.

CAUSE OF FAILURE

The cause of the failure is plainly evident. Due to corrosion, the bottom head parted from the rest of the boiler on a circumferential line just below the line of rivets. This line of rupture is indicated by *A* in Figs. 4 and 7. As soon as the head became detached the entire pressure was thrown upon the base flange *B*, which parted at the line of rivets and allowed the boiler to be shot upward. Assuming that the steam pressure did not exceed 150 pounds per square inch, the total pressure on the bottom head, including the weight of the water, amounted to approximately 290,000 pounds. The portion of the bottom head which was detached was found intact after the explosion.

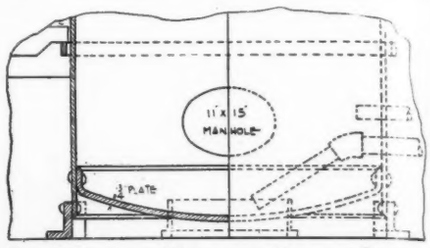


FIG. 5. BOTTOM HEAD AND BASE OF BOILER WHICH EXPLODED

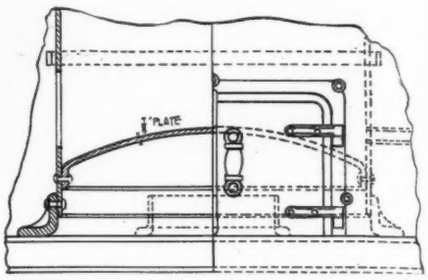


FIG. 6. BOTTOM HEAD AS FITTED TO LATER BOILERS OF THE CLIMAX TYPE

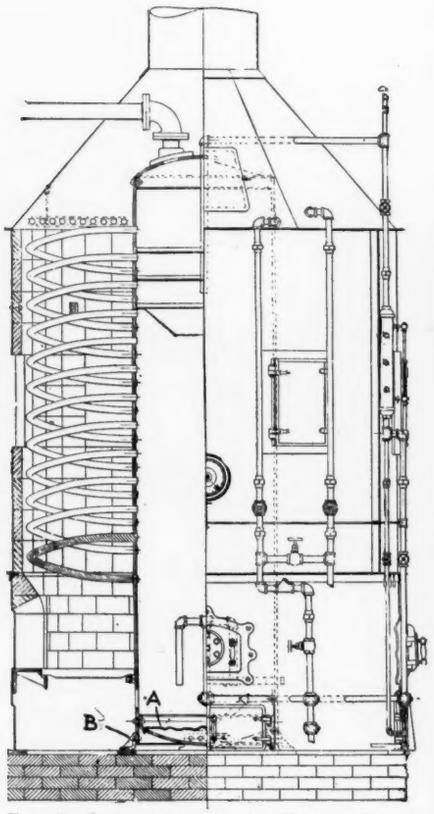


FIG. 4. SECTION THROUGH BOILER SHOWING LINE OF RUPTURE

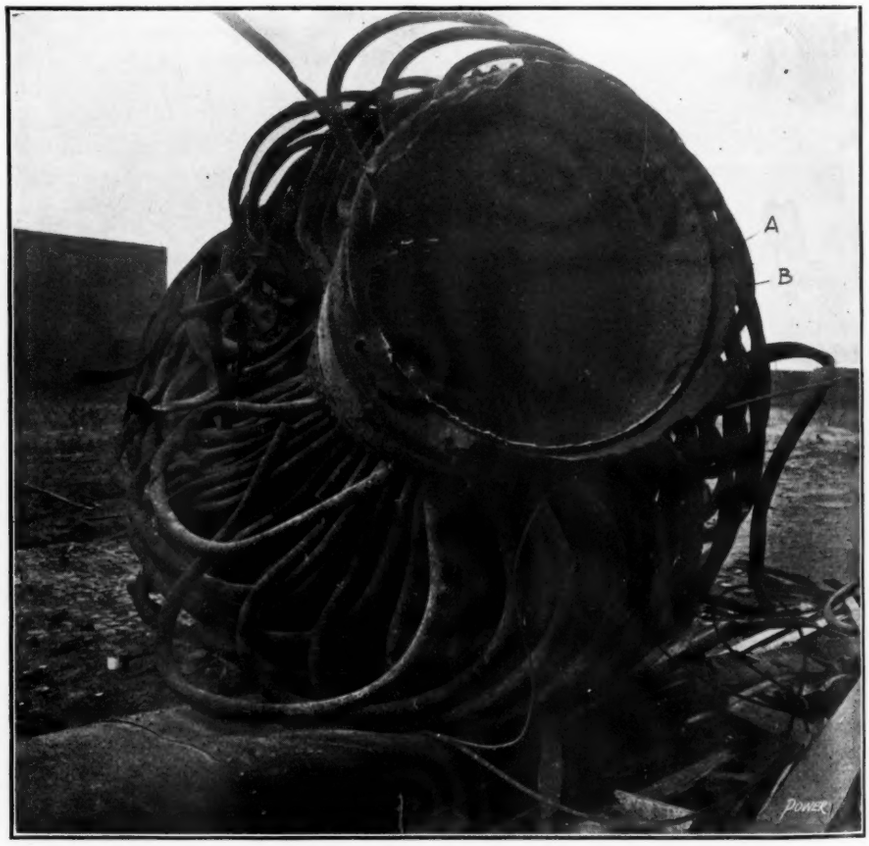


FIG. 7. BOTTOM OF DRUM SHOWING WHERE HEAD WAS TORN OFF

Although the head was originally ¾ inch thick, it was found that the metal had wasted away to a thickness of approximately ¼ inch on the line of rupture,

and the greater part of this corrosion had taken place on the outside of the head. Owing to the construction of the setting this part of the boiler was inaccessible for inspection.

The whole area of the head was corroded to a great extent but at no part was the metal so thin as at the line of rupture. The fact that this followed almost a true circle around the head would seem to indicate that there was some underlying reason for the corrosion being greatest at this point. One possible explanation of this is as follows:

Owing to the head being bumped to a radius equal to the diameter of the drum, instead of the radius of the drum, the true curvature necessarily had to be deviated from, to a considerable extent, at the flange. With the temperature changes and changes in pressure on the lower head, the latter worked to a greater or less extent, tending with an increase in pressure to assure the form of a hemisphere. With this working of the head the greatest movement naturally occurred on the line of the greatest curvature. This loosened the rust and bared the metal, allowing more rust to form, which in turn became loosened and the action was repeated; hence the decreased thickness of the metal at this point. As the metal became thinner, the effect of the working of the head became greater, until a crack probably developed, resulting in the initial rupture.

At the coroner's inquest undoubtedly many interesting facts will be brought out.

The Career of H. A. Humphrey

Received instruction from Dr. John Perry and Prof. W. C. Unwin. Was closely associated with the late Dr. Ludwig Mond. Inventor of Humphrey pumps and compressors.

Herbert A. Humphrey was born in London and received his technical training in the engineering departments of the Finsbury Technical College and the Central Institution at South Kensington. He had the advantage of receiving instruction under Dr. John Perry, F. R.S., and Prof. W. Cawthorne Unwin, F. R. S., two of the best teachers of engineering in Europe. Some years later, Mr. Humphrey, as the result of original research work, was elected a Fellow of the City and Guilds Institute, being the first to receive this honor.

On leaving college, Mr. Humphrey entered the works of Messrs. Heenan & Froude, Ltd., at Manchester, and was for some time in the bridge-building and constructional iron-work department. He was then made manager of the engineering department, and later was transferred to take full charge of the important engineering works belonging to the same firm in Birmingham. He next entered, as engineer, the large chemical works of Messrs. Brunner, Mond & Co., which company has works in several parts of the country and employs some 4000 workmen. He started and organized several new departments and while with this firm became closely associated with the late Dr. Ludwig Mond, F. R. S. Mr. Humphrey studied Doctor Mond's gas-producer plant and read a paper before the Institution of Civil Engineers, giving for the first time a complete balance sheet of all heat quantities entering into the gasification of bituminous fuel in a large commercial plant. It was at Brunner, Mond & Co's. works that Mr. Humphrey installed the first gas engines exceeding 400 horsepower erected in England, and ever since he has been closely connected with the development of large gas engines and become recognized as one of the leading experts on this subject.

It was at Doctor Mond's suggestion that Mr. Humphrey established himself in London as a consulting engineer, and this enabled him to take up a great deal of interesting work and to closely associate himself with Doctor Mond's group of companies. One of these companies was the South Staffordshire Mond Gas (power and heating) Company which obtained its parliamentary powers to distribute producer gas over a large area after a very severe fight against local opposition in both Houses of Parliament. Mr. Humphrey designed the central-station plant and superintended its erection at Dudley Port and so was instrumental in starting the first public supply of gas for power and furnace purposes.

H. A. Humphrey

Mr. Humphrey's constant connection with large gas engines caused him to endeavor to discover an internal-combustion engine which should be free from the many defects and complications of the existing types and at the same time should solve the turbine problem and give a high-speed rotary motion free from cyclic irregularity. The outcome of several years' work in this direction has resulted in the development of the internal-combustion pumps and compressors which bear his name.

Mr. Humphrey has been consulting engineer to many well known and important works and has been elected to full membership of the Institutions of Civil, Mechanical and Electrical Engineers respectively. He is the author of several papers read before these institutions in connection with which he has received the Telford gold medal and Telford premium, and the Willans gold medal. The latter is only given once in six years, for the best paper in that period, and is therefore specially prized.

The rapid development of the Humphrey pumps and compressors has now made it necessary that Mr. Humphrey should devote practically all his time to the affairs of the Pump and Power Company, Ltd., formed as a parent company to grant licenses for the manufacture of Humphrey pumps and compressors in all important centers of the world.

A new kind of steel, under the name of "cementation steel," is, we hear, being manufactured at Chester, Penn. It is of the high-carbon variety, but contains more sulphur and less manganese than ordinary tool steel. The steel is so dense that it remains, so it is said, unresolved under the microscope with a magnification of 1200 to 1600 diameters, although that of the open-hearth, crucible and bessemer steels can be resolved with a magnification of 100. Its elastic limit is said to be very high, and its ultimate strength 80,000 pounds. It is intended specially for cast gears, crank shafts, connecting rods and so on. The process of manufacture takes from six to eight weeks.

Carbonic acid in the atmosphere arises from respiration of animals, from processes of combustion, from the decomposition of organic substances. Boussingault estimated that in Paris the quantities of carbonic acid produced every 24 hours were: population and animals, 11,895,000 cubic feet; combustion, 92,101,000 cubic feet.

Inquiries of General Interest

Horsepower of Belt

What horsepower will a 12-inch double-leather belt transmit running over a 6-inch pulley making 200 revolutions per minute?

H. P. B.

If the working stress is 60 pounds per inch of width, a belt traveling 550 feet per minute will transmit 1 horsepower for each inch of width. If the working stress is 30 pounds per inch of belt width, it will have to travel 1100 feet per minute to do the same work. Most of the rules given for the horsepower of belting fall between these extremes.

Neglecting the thickness of the belt, it will travel over the pulley at the rate of 320.7 feet per minute, and with a stress of 60 pounds per inch of width, will transmit

$$\frac{320.7}{550} \times 12 = 6.997 \text{ } horsepower$$

With 30 pounds stress per inch of width the belt will transmit

$$\frac{320.7}{1100} \times 12 = 3.498 \text{ } horsepower$$

The horsepower which a belt will transmit under proper conditions falls within these limits, but by excessive tension which destroys its elasticity and shortens the period of its usefulness, it may be made to do much more.

Banking Fires

I have two boilers. During the day they are loaded to their capacity but at night the load drops to less than one-half of that during the day. Do you think it advisable to bank one fire every night, or use both, considering the cracking and breaking of tile and for economy?

B. B.

During the day run, while the fires are being forced, the burning of the fuel is going on under the best conditions and each pound of carbon is converted into CO_2, giving up nearly, if not quite, all of the 14,500 heat units it contains.

At night, when the demand for steam becomes less, the heat units liberated must be reduced in number. If this is accomplished by reducing the air supply to the fire, as it must be if both boilers are operated, much of the carbon instead of giving up 14,500 heat units per pound in being burned with plenty of air will give up approximately only 5000 heat units per pound. It is probable that more than twice as much coal is burned in operating both boilers on the light load than is necessary if only one boiler is used. With proper attention given to avoiding sudden furnace temperature changes there is little danger of cracking the tile.

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it.

Viscosity and Flash Point

What is meant by the viscosity and the flash point of an oil, and how are they found?

V. F. P.

Viscosity is the resistance a fluid offers to its separation into drops or particles. It is measured by the time required for a given quantity of oil to flow through an orifice. As there is no accepted standard viscosimeter the term means nothing unaccompanied by the name and make of the instrument used in the determination of the viscosity of the liquid.

The flash point is the temperature at which the oil gives off inflammable vapor and is found by slowly heating a small quantity of oil, in which a thermometer is inserted, until a vapor is given off which will flash or burn on the application of the flame of a burning match, candle or gas jet.

Steam Bound Pump

How does a steam pump act when it is steam bound, and what kind of a noise does it make?

S. B. P.

This term is usually applied to pumps which are used for pumping hot water from open heaters or receiving tanks when they fail to operate because the hight of the water above the suction valves is not sufficient to open them, and the pump, having no work to do because there is no water in the cylinder, runs away, clattering or pounding according to the steam pressure and the amount the throttle valve is open.

Air Bound Pump

How does the water end of a pump act when it is air bound, and what does air bound mean?

A. B. P.

A pump is said to be air bound when the air pressure in the cylinder in front of the advancing piston is not sufficient to open the discharge valves and too great behind the piston to permit the water to flow to the pump. It is caused by large clearance space in the water cylinder, by leaking piston and valves and by a high suction lift or by a combination of all three conditions. An air-bound pump will run at a high rate of speed and perhaps knock at the ends.

Relative Diameter of Pump Cylinders

If a pump working against a pressure of 145 pounds per square inch with a steam pressure of 130 pounds per square inch, 16 feet lift has an 8-inch steam cylinder, what will be the size of the water cylinder?

A. G. C.

Assuming that 85 per cent. of the boiler pressure is realized in the steam cylinder and that the piston moves at the rate of 50 feet per minute, the foot-pounds of work done per minute will be

$$130 \times 0.85 \times 50.26 \times 50 = 277{,}686.5.$$

If the friction of the pump and the water absorb 10 per cent. of this, there will be left for the work of lifting the water

$$277{,}686.5 \times 0.90 = 249{,}917.85$$

foot-pounds per minute. The 145 pounds pressure per square inch against which the water is pumped is equivalent to 333.5 feet of head, which, added to the 16 feet of suction lift, makes 349.5 foot-pounds of work for each pound of water delivered per minute and the total will be

$$249{,}917.85 \div 349.5 = 715$$

pounds of water delivered per minute. As the water piston travels at the rate of 50 feet or 600 inches per minute, its area is the quotient of the total weight by the weight of 600 cubic inches of water; 600 cubic inches of water weigh 21.65 pounds.

$$715 \div 21.65 = 33.02$$

square inches area of water piston.

The diameter of a circle whose area is 33.02 square inches is approximately 6½ inches and is the diameter of the water cylinder required by the conditions named. In commercial practice a water cylinder 5 inches in diameter would be selected and the steam pressure reduced at the pump by throttling.

Siphon in a Vacuum

Consider a regular siphon being placed in a closed receptacle and a vacuum obtained, would the siphon cease to operate, or in other words, does the siphon depend alone on the air pressure?

S. I. V.

A siphon will not operate in a vacuum. There must be pressure enough on the surface of the liquid at the higher level to raise it to the highest point in the system.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.
150 Michigan Avenue, Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $4 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 16 Shillings.

Entered as second class matter, April 2, 1908, at the post office at New York, N. Y., under the Act of Congress of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

During 1909 *we printed and circulated* 1,875,000 *copies of* POWER.

Our circulation for October, 1910, *was* 132,000.

November 1..... 33,000

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

Contents

	PAGE
Power Plant of McCormick Building...	1922
Do We Waste 95 Per Cent. of Our Fuel?	1925
Installing Tubes in Boilers.....	1926
Boston Elevated Receiver Explosion...	1928
The Marine Engineer and His Work...	1929
Safety Stops for Steam Engines.....	1930
Darky Engineer Had a Hot Crank Pin..	1932
Tests on a 12x30 Corliss Engine.....	1933
Locomotive Boiler Explosion.....	1934
Notes on Causes of Boiler Failure.....	1935
Novel Method of Delivering Coal.....	1936
Induction Motor Hand Starters.....	1937
Generators with Commutating Poles...	1940
The Sweeper Should Have Been Promoted	1940
Willans & Robinson's Two-stroke Cycle Engine	1941
The Gas Turbine.....	1942
A Homemade Carbureter.....	1942
Practical Letters: A Loose Crank Pin....Curing a Knocking Slide Valve .... Failure of Boiler under Test....What Causes the Engine to Run?.... Trouble with Metallic Packing.... A Quarter Turn Drive....Feeding Boilers through the Blowoff Connections .... Metal for Cylinders ....Diagrams for Criticism....A Problem in Hot Water Heating..	1943-1945
Discussion Letters: Cracked Cylinder .... Accuracy of Water Meters....Painting Smokestacks....Trouble with a Gravity Loop....National Conventions.... Safety Device for Rope Drive.... Engineers' Wages....Do It Right or Quit....Useful Belt Drives.... License Laws....Trouble with the Belt	1946-1949
Progress in Flue Gas Analysis.....	1950
Seven Killed in Boiler Explosion.....	1955
The Career of H. A. Humphrey.....	1957
Editorials	1959-1960

Power and The Engineer

Editorial

The Value of CO_2 Indicators

A report of the Committee on Power Generation of the American Street and Interurban Railway Engineering Association did not, to say the least, do the CO_2 recorder any harm by fulsome praise. Both G. H. Kelsay, who handled this particular subdivision of reports, and C. E. Roehl, who wrote that portion of the report dealing with forced draft, say that the hopes, which had been aroused by the introduction of CO_2 recorders, have not been realized. The boiler efficiency is not at all proportional to the percentage of CO_2 in the flue gases and the CO_2 recording apparatus is often found in an inoperative and neglected condition. Mr. Kelsay is hopeful, however. "Gas analysis as applied to boiler-room practice will," he says, "no doubt gradually adjust itself into methods that will be found very beneficial in developing and maintaining higher boiler economies; but it is possible that overdrawn ideas have been entertained by many engineers as to its value; also many engineers have failed to give the subject the attention that it deserves, and would probably find more merit in the analysis of flue gases than they now think."

There is no doubt that the lower the temperature of the gases going to the uptake, the less heat will be carried up the chimney; but one might easily buy a thermometer, put it into the uptake, tell the boiler attendant to keep the temperature as low as possible, and still burn as much coal as before, or more. If the low temperature were produced by letting in an unnecessarily large quantity of cold air, he certainly would burn more. It is quite possible, probable in fact, that his boiler-room expenses will be less, if he lets the gases go from the boiler at a somewhat high temperature, rather than at a temperature not much above the heating surface; for, he would make the heating surface "earn its keep" and get along with less boilers and run with furnace conditions more conducive to perfect combustion.

But, because of these things, the importance of flue-gas temperature as a factor in boiler performance should not be disparaged, its measurement discouraged and the instrument by which it is measured condemned.

It appears to be true that the best overall boiler efficiency is not obtained when the furnace is making the largest percentage of CO_2. Just why this is so has not been satisfactorily explained. It is probably due to the fact that a boiler, to be of any use as a boiler, has to make not only a large *percentage* of CO_2, but a large *amount* of it. If the air were let in so parsimoniously that each atom of oxygen in it must find an atom of carbon in order that the combustion may be complete, and were kept in the furnace until this complete chemical union took place, the percentage of CO_2 would be high, but the process would be so slow that the boiler would do no work. In order to get enough coal burned in a given time, it must be supplied with a surplus of air, such as will allow the combustion to go on rapidly and, with this surplus air, the percentage of CO_2, somewhat over twenty for the ideal case, will fall to from twelve to sixteen for the best usual running conditions. The better means one has for effecting a prompt and ultimate mixture of the gases, the better the furnace is arched and baffled, the higher percentage of CO_2 can be carried without making CO, which is so destructive to the efficiency.

Because the best boiler efficiency is not attained when the percentage of CO_2 exceeds twenty is no reason to decry the benefit of flue-gas analysis. Because a man who can hardly read the figures on the pressure gage cannot gather all the significance of its indications is no reason to condemn the CO_2 recorder. That a rather complicated and very delicate instrument should be often out of working condition when placed in charge of a man whose finest work is usually done with a monkey wrench, is not surprising. To the man who understands its significance, a knowledge of the CO_2 content of his flue gases is of value, and the CO_2 apparatus will give it to him if it has the right kind of care and supervision.

The Hydrostatic Test

There have been during recent years three instances in which disastrous boiler explosions have been prevented by tracing to its source and finding the cause of the leaking steam which appeared through the brickwork of the boiler settings.

It is generally, if not universally, admitted that the lap-seam form of boiler construction which prevents the shell of the boiler from taking the f
true cylinder under any conditi
sure or lack of it, but still
change of shape for every

pressure, causes a bending of the sheet at or near one of the rows of rivets which finally produces cracks.

These cracks can be seen only by unmaking the joint, and even when suspected to exist cannot be discovered. But the fact that under ordinary working pressure they have made their presence known before the sheet was weakened to the breaking stage points a way to their discovery before the danger line is reached. Periodic intelligent application of the hydrostatic test fifty per cent. in excess of the pressure at which the safety valve is set will in most if not all cases reveal any dangerous weakening of the sheet before it results in failure.

Something like two years ago a boiler used by a contractor in Boston failed under the hydrostatic test when the pressure reached a point three pounds above that at which the safety valve was set. It is, of course, uncertain how many times the varying steam pressure would have bent the cracking sheet before it would have yielded to the regular working pressure and another hidden-crack explosion would have passed into history.

While the hydrostatic test is not considered by all as desirable, it seems to be and probably is the only safe method of determining if a boiler shell or drum will stand a pressure slightly in excess of that for which it is designed. It is certain that it will reveal weaknesses in material and structure that can be detected in no other way and should be applied at intervals to all boilers used for pressures exceeding the ten pounds per square inch usually employed for heating purposes, care being taken not to stress the metal above its elastic limit.

Boiler Explosions

Boiler explosions are becoming almost as common as automobile accidents. The latter have now ceased to excite more than a passing interest, and the average individual upon reading an account of one usually dismisses it from his mind with the chance remark: "Well, if they will take the risks they must be prepared for the consequences." The public, however, cannot afford to regard boiler explosions in a similar light. It is a question of vital importance not only to the engineer and fireman but to the public at large, involving the personal safety of everyone employed in a building in which a steam boiler is in service. When one stops to consider that nearly every large building in New York City is equipped with one or more boilers upon whose safe operation hangs the lives of scores of persons, the gravity of the situation is apparent.

The recent explosion at the works of the American Manufacturing Company, described elsewhere in this issue, strongly emphasizes two points: First, the necessity of having all parts of the boiler accessible for inspection; second, the necessity of a rigid inspection. Failure to comply with the former requirement, however, is no excuse for laxity in the latter. If any part of a boiler is inaccessible, it is the duty of the inspector to demand that the owners provide means of its inspection, and furthermore, he has the power to withhold the certificate until satisfied that the boiler may be safely operated under the particular operating conditions.

It is possible that the coroner's inquest may bring out facts that will more closely fix the blame for the disaster, but whatever the verdict, the two points just mentioned stand out as self-evident facts.

Engineering Carelessness

"William Blank was badly scalded here this afternoon at the plant of the ——— ——— Company, and will die. He entered a boiler to clean it out, and was seen to leave it soon after to get something. The engineer, not noticing that he had returned to the boiler, turned on the steam and scalded Blank so badly that he was removed to the hospital, where it is stated he cannot live."

The above is merely one of a dozen of such newspaper items that appear from time to time. When the article is analyzed, it will be seen that there is something more to it than the mere statement of facts that a man was probably scalded to death because the engineer of the plant opened a steam valve without knowing that a man was in the boiler.

The analysis shows that there was lack of system in the plant. If there had been some method of tagging the stop valve located between the boiler and the steam main, bearing the words "Keep Closed," there would have been no excuse for anyone to open that valve until the tag had been removed.

It is difficult to conceive of any engineer connecting one boiler to another after making repairs or washing out, without first being assured that the boiler was ready for connecting. It is more difficult to understand why any sane man should turn live steam into an empty boiler, as stated, although it is quite possible that the clipping is in error. It may be that the man was in the empty boiler and the engineer decided to blow down another boiler that was under steam, while the blowoff valve on the cold boiler was open.

To the man who was scalded it does not make any difference how the deplorable accident occurred. The engineer was to blame for the accident and the scalded man is in danger of losing his life. An engineer who opens a valve under similar conditions without knowing, as far as human knowledge permits, that he can safely do so, is not only negligent but is criminally careless and not fit to have charge of a steam plant.

The incident furnishes a lesson which the careless engineer might well heed. It is better to climb up on top of a boiler a dozen times and make sure that no one is in it before closing it up or blowing down another boiler without knowing the blowoff of the cold boiler is closed, than to run the chance of scalding a man to death.

The engineer may try to justify his actions when they turn out disastrously, but that will not remove the consciousness that the accident could have been avoided had proper precautions been taken.

A mistake which results in the killing of a fellow workman will never be repeated by the man who made it. By taking proper precautions and using common-sense methods in doing the daily work around the plant, such fatal mistakes may be avoided.

Obsolete Literature

The following statement appears in a recent edition of one of the engineering handbooks: "While our conception of the fundamental principles of electrical science can of necessity have undergone no very considerable alteration, those essential details which in effect constitute the working data of the engineer have so altered and grown that books published only a few years ago are already obsolete." There can be no question as to the truth of this statement; in fact, it applies not alone to the electrical field but to all branches of engineering. For this reason too much care cannot be exercised in the selection of reference books.

In the catalogs of many publishers, as well as dealers, there is nothing in the descriptive matter to indicate the "out-of-dateness" of the book advertised. The same descriptions under which they were sold when just off the press are frequently used in advertising them as long as it is possible to command sales. It would be unfair to accuse publishers and dealers of attempting to obtain money under false pretenses; instead the fault undoubtedly lies in the fact that they do not stop to consider how fast conditions are changing, and in many instances the men who finance the publication of books know nothing of the subjects treated.

The ordinary buyer of technical literature has not as good an opportunity to become familiar with the subjects covered as have the publisher and bookseller. But the latter do not always improve their opportunities. Therefore, after a purchase has been made, and money parted with, it is often found that the book is not only valueless, but if made use of in practice might do infinite damage. In view of these conditions, it is well for a prospective buyer to first make a personal inspection of a book and before accepting its contents as authentic, to check its statements with the uptodate practice brought out in current technical periodicals; also, if possible, to note the opinions as expressed in the "book-review" columns of these mediums.

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news.

Induction Oxidizer System

This device has been designed with a view of preventing smoke and producing a high rate of combustion. It consists of an air flue built in the bridgewall, as shown in Figs. 1 and 4. On top of the bridgewall a base of tile is placed in which tile deflecting tubes are set. The base and deflecting tube are shown in Fig. 5; Fig. 2 shows them assembled. The tubes are hollow and are perforated, the holes being so placed that the jets of air converge, as shown in Fig. 3.

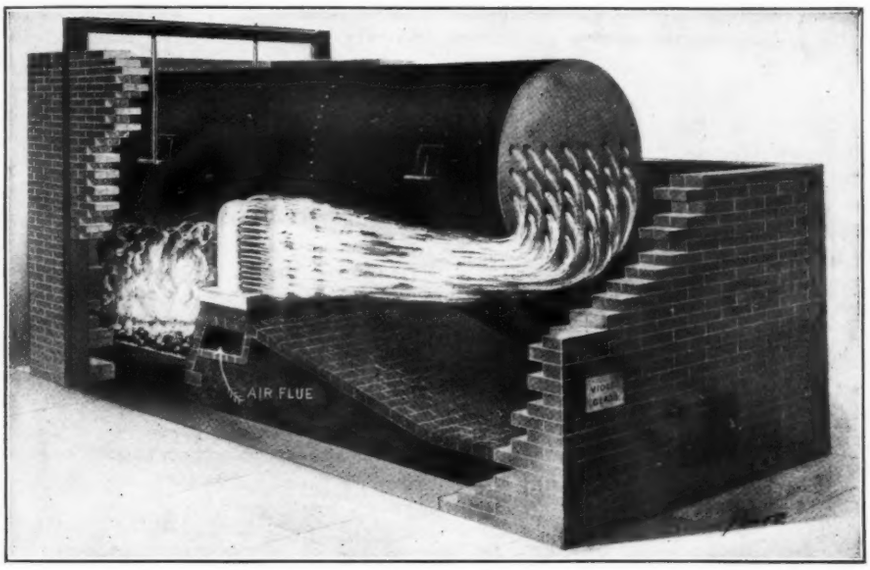


FIG. 1. SHOWING OXIDIZERS AND AIR FLUE

Air is admitted to the combustion chamber through the air flue and deflector tube, escaping through the air holes. It is claimed that but 1 per cent. of the air used in the combustion of the fuel passes through these tubes, and in so doing is heated up to 1292 degrees Fahrenheit. Consequently the air is expanded in volume, which causes it to issue from the numerous air jets of the deflector tube with considerable velocity. This heater air, it is claimed, ignites the fuel gases that have passed the bridgewall and deflector tubes.

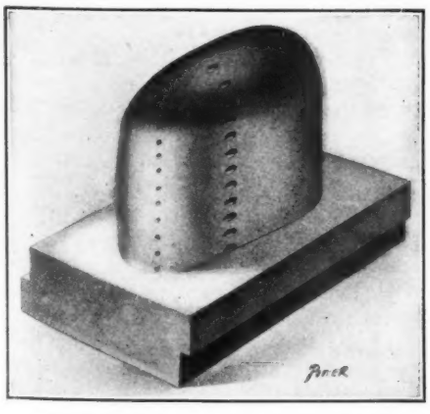


FIG. 2. BASE AND DEFLECTING TUBE

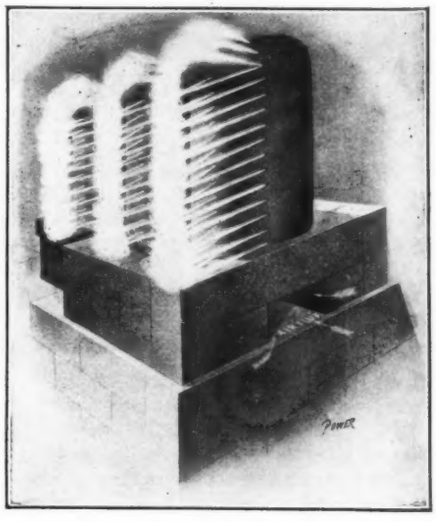


FIG. 3. SHOWING AIR JETS

The builders state that these jets of air set up an induced draft through the grates, which greatly increases the draft and increases the capacity of the boiler.

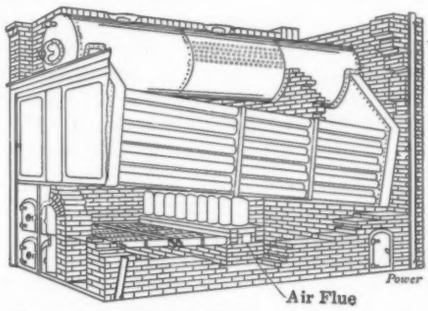


FIG. 4. OXIDIZER UNDER WATER-TUBE BOILER

This system requires no attention after being installed, and it is said that the tile or firebrick deflector tube and base are practically indestructible under the action of the furnace temperatures found in boiler practice.

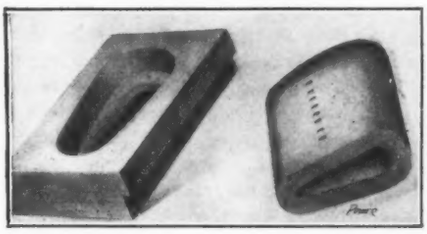


FIG. 5. BASE AND DEFLECTING TUBE

This system is made by the Induction Oxidizer Company, Lancaster, Penn.

Flexible steel belt conveyers have been recently put on the market by a Swedish manufacturer and a number of installations of this new type of conveyer have been made in northern Sweden. A hardened-steel ribbon, or belt, from 8 to 16 inches wide and 0.03 to 0.04 inch thick, runs flat on the bottom of a trough with sloping side boards. The belts are made in lengths up to 328 feet, and longer belts can readily be obtained by riveting two or more lengths together. The belts are run on wooden pulleys covered with rubber belting. The driving pulleys should be 3.28 to 4 feet in diameter, and the idler pulleys 16 to 20 inches.

It is stated that these belts are suitable for transporting ore, coal, planks, wood stumps, coke, cement slag, ashes, sawdust, etc., and that the power cost and cost of upkeep and repair are inconsiderable. In case of fracture, a riveted piece can be inserted. They are known as Sandvik belts and are made by the Sandvikens Jernverks Aktiebolag, Sandviken, Sweden.

Reliability of Steam Meters*

By R. J. S. Pigott

Anemometer, or Jet-turbine Type

Holly and Lindenheim: Holly's device was a small vane which operated by a small bypass, with entry pointing upstream and discharge pointing downstream; the vane wheel drove a clockwork integrating mechanism through a gland. The errors in this meter are: Friction of the gland or stuffing box on the vane-wheel spindle, variable friction losses in the bypass system and the absence of a correction device for variation of steam pressure.

Lindenheim's machine was very similar to Holly's, but added a correction device for variation of steam pressure, and in this way was somewhat superior; but both are rendered very unreliable by the fact that friction of the vane-wheel spindle bearings and gland has such an enormous influence on the correctness of the reading.

Throttle Disk Type

The Bendemann, Gehr, St. John, Sargent and several other meters are of this type. The means of operation in all cases is some form of throttling disk or cup in a passage or over a seat, loaded so as to offer a slight resistance to the flow of steam through the passage. Consequently, as more steam flows through the meter the disk or cup is forced up from its seat, so as to expose more area for the steam to flow through, accompanied by an increase in pressure drop through the machine. The rise of the disk is some function of the flow, usually not a straight-line function, as the position of the disk is influenced by eddy currents, which vary with rates of flow and with the shape of the disk and seat or passage.

The Bendemann meter consists of a disk floating in an inverted conical passage, in which the steam is flowing upward, the spindle of the throttle disk is carried up into a glass tube (under pressure) and the scale is attached to the tube. Thus the friction error of a stuffing box on the spindle is avoided, but no recording device is attached to the meter. In a later modification, the spindle was extended downward and ended in a long taper plug partially closing an orifice. The amount of steam released from this orifice, therefore, varied with the main flow, and was condensed and passed through a small water meter. The St. John meter has a taper plug, moving in an orifice vertically, the movement being transferred by a system of levers, through a stuffing box, to a recording sheet. There is no device on these meters to correct for pressure variation. The Sargent meter has a conical cup, fitting over a conical seat; the motion of the cup spindle is transferred without levers through a labyrinth stuffing box, and has a pressure-variation correction in the shape of a bourdon gage.

This type of meter has the advantage of large movement of the throttle disk over the range, which gives open scales; but the friction of glands and lever systems introduces an error which may overbalance this. The throttling action tends to erode disk and passages, and must eventually destroy the accuracy of the meter with wet steam. If the meters are spring loaded, or use spring-pressure corrections, they become subject to the additional inaccuracies of springs. The bulkiness of this type of meter prevents its use in anything above 6-inch pipe sizes.

Electric Type

An electric meter was proposed by Professor Thomas, in which the temperature of steam is taken before and after passing an electric-heating coil; the energy sent into the coil is also measured. If the quality and pressure are known the above quantities give a measure of the flow, which is absolutely accurate; but the quantity of electrical energy needed becomes enormous if the steam is 2 or 3 per cent. wet, practically prohibiting the meter. For superheated steam or dry gases it is a very good means of measurement and there is no limit to its size.

Pitot Type

The remaining forms of steam meter are those in which difference of pressure is employed—working on the principle of the Pitot tube and the Venturi meter. These meters have the best opportunities for accuracy, since there are no moving parts to stick or cause friction, and no parts to wear from erosion. They can also make use of mercury and other accurate differential gages.

The advantages of the Pitot tube type are obvious—nothing to do to the piping but put in a small Pitot plug; the recording device may be at any reasonable distance from the point of measurement, and may be made portable. But the total difference of pressure amounts to only ½ inch of mercury at ordinary velocities, so that a very slight leak or bubble of air in the piping to the meter recorder is sufficient to throw it off, and only a most delicate recording device can be used. The Venturi type has the additional advantage of being designed for almost any difference of pressure, allowing of a robust recording device and not being easily affected by small leaks.

One feature which is not taken account of by any meter, and which has a large effect, is the variation of moisture in the steam.

The Pitot tube, Venturi and electric meters are most affected by variation in quality, but their accuracy in actual measurement partially offsets this when the quality variation is not compensated for.

To sum up, the throttle-disk meters suffer, both in measurement and mechanically, from moisture, are usually impaired in value by friction in the mechanism, and are prohibited in large sizes by bulk and expense of installation. In small sizes they are reasonably good.

The electric meter is most accurate, but is too expensive to operate for wet steam, and requires knowledge of the quality to be of any value whatever.

The Pitot meter is simple, durable and easy to install and operate, but is affected by very slight leaks or pulsation in the steam mains.

The Venturi meter has the same advantages as the Pitot tube, with the additional point of much greater differences of pressure and less delicacy. It is probable that the Venturi form of meter will offer the most reliable and accurate means of measurement.

All the meters are affected by variation in quality, and some by variation in pressure (when no compensation device is used). In the present state of the steam meter, it seems as if the safest way to measure the steam output is by means of a Venturi meter placed in the feed line to the boiler. By this means results can be secured which give the output to 1 per cent.

*Portion of the report of the Committee on Power Generation of the American Street and Interborough Railway Engineering Association, Atlantic City, October 10-14.

Elevator Tank Fails

At 8:30 o'clock Saturday morning, October 22, the hydraulic elevator tank in the engine room of the Clarendon hotel, Brooklyn, N. Y., failed, with the result that the entire plant was put out of service. Six men were more or less seriously injured, none fatally, however. The tank was 5x9 feet in size and built of ⅜-inch plate with single-riveted lap joints. It had been in service for about 15 years. The normal pressure in the tank was 130 pounds. The rupture started at the longitudinal seam.

When the tank failed the pressure in the system forced the tank from its foundation and threw it across the room. In so doing two 4-inch engine leads carrying 100 pounds steam pressure; six 2-inch leads for various pumps; an 8-inch pump-suction line and a 6-inch pump-discharge line were broken. The main switchboard, one end of which extended across the path of the tank, was wrenched loose and turned partly around. A 12 and 10 by 8-inch duplex pump used for auxiliary elevator service, was moved off its foundation about 2 feet. A 10x12-inch Ames engine driving a 35-kilowatt generator and standing in the path of the tank was disabled.

The total damage to the plant amounts to about $5000. Temporary central-station electric service was installed within

three hours after the accident had occurred.

Asher Nelson, chief engineer of the Clarendon plant, will conduct an investigation to discover, if possible, the exact cause of the failure. Accidental over pressure is the theory which he most favors at this writing, although the fact that the tank had been in use for about 15 years points to the probability that the joint may have become weakened to such an extent as to cause the failure.

NEW PUBLICATIONS

STANDARD HANDBOOK FOR ELECTRICAL ENGINEERS. (Third Edition.) Published by McGraw-Hill Book Company, New York, 1910. Soft leather; 1500 pages, 4x7 inches; liberally illustrated. Price, $4.

This excellent reference book has been extensively revised and the contents have been rearranged slightly. The quantity of data and information has been considerably increased, but the illustrations remain very unsatisfactory in most instances, and the treatment in many places is too concise to be explicit—for example, the statements in paragraphs 282 to 286, section 3, relating to the measurement of power in electrical circuits. There are many statements that should be elaborated or conditioned, as the definition of an atmosphere, on page 20; that of capacity, on pages 26 and 29; that of resistance, on page 27; the statement in paragraph 158 of section 7 and most of those resulting from the one cited. This statement is really worse than dogmatic or obscure; it is untrue, if the author means what is usually meant by the inductance of a direct-current armature—namely, the inductance of those coils short-circuited by the brushes during commutation. The total ampere-turns per pole in the armature winding are not a factor in the inductance of the short-circuited coils, unless there be assumed a fixed ratio between the number of coils simultaneously short-circuited and the total number on the armature, which would be impractical. However, the author is a thoroughly capable designer of electrical machines and doubtless meant something else than what he said.

The book is deficient in several respects, notably in the discussion of the Edison storage battery and in that no attention whatever has been paid to arc-lighting dynamos.

There are also some obvious inaccuracies, notwithstanding the full revision given the book. For example, on page 31: "Magnetomotive force is the force per unit cross-section of the circuit." The geometry of the magnetic circuit has nothing whatever to do with the m.m.f. of the exciting coil, which is solely a question of convolutions and electric current. Again, on page 300: "The flux in direct-current depends on the ampere-turns but in alternating-current magnets it depends on the voltage-turns." We do not pretend to know what voltage-turns are, but if any magnetic flux can be produced by volts and turns, without any amperes, we should enjoy seeing it done.

In the final formula of paragraph 94, section 5, the symbol R should be a P. Paragraph 58, section 5, does not belong in a discussion of field magnets. Paragraphs 60 to 73 of this section appear to have been collated at random.

The foregoing blemishes are typical of some sections of the book. Other sections are remarkably free of defects and weak spots. These few have been pointed out not in any carping spirit but with a view to inciting the editors to wipe off their spectacles more thoroughly, and remove the flyspecks from what would otherwise be a shining example of reference-book construction.

RULES AND FORMULAE, WITH SUGGESTIONS PERTAINING TO GOOD PRACTICE, INDORSED AND ADOPTED BY THE INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION. Published by the association and supplied by the secretary, 95 Liberty street, New York City. Sixty-five pages, 3½x5¾ inches; cloth. Price, $1.

This little work was indorsed at the Louisville, Ky., convention as expressing the consensus of opinion of the association on what constitutes good practice in the construction and management of steam boilers.

It supplies in a concise form rules, information and tables of value to those who are engaged in designing, inspecting and operating steam boilers. Especial attention is given to a modification of D. K. Clark's formula for the staying of flat surfaces with riveted screw stays. Otherwise there is little or no original matter in the book, as it consists of selections from many sources, which are believed to be the best. Unfortunately, the book is not indexed.

THE CONSTRUCTION OF GRAPHICAL CHARTS. By John B. Peddle. Published by McGraw-Hill Book Company, New York, 1910. Cloth; 115 pages, 6x9 inches; 58 illustrations. Price, $1.50.

Professor Peddle has made a fine "start" in his little volume of chart exposition, but it is not much more than a start. The plotting of charts to solve a number of equations is explained—or rather illustrated—very concisely, and the book should be very useful to engineers who have to deal with the forms of equations covered, provided they are already well versed in the principles of the various charts and require merely a typographical substitute for memory. If the author had elaborated his work to the extent of making his explanations more elementary and increasing the number of examples of each form of equation, the book would have been instructive and valuable to those who have need to plot such charts but have not had the mathematical training presupposed by the author.

HENDRICKS' COMMERCIAL REGISTER OF THE UNITED STATES. Published by S. E. Hendricks Company, New York, 1910. Price, including express charges, $10.

This is the nineteenth annual revised edition of Hendricks' well known "Register." It is considerably larger than that of previous years and contains the names of the manufacturers of over 5000 articles, none of which have appeared in any previous edition. The total number of classifications in the present edition is 35,481, each representing some machine, tool, specialty or material required in the architectural, engineering, mechanical, electrical, railroad, mining and kindred fields. The total number of names and addresses is upward of 350,000.

By virtue of the manner in which classification is carried out, the register may be used for mailing purposes as well as for purchasing.

"Exhaust Steam Heating Encyclopedia" is the title of a profusely illustrated 117-page book describing and illustrating commercial systems of exhaust steam heating, which is being sent out by the Harrison Safety Boiler Works, of New York City. Other subjects discussed are exhaust steam-heating in connection with condensing plants, the application of low-pressure turbines, the use of exhaust steam in absorption ice machines, etc. Over 30 pages are occupied by tables and engineering data of value to those who design, install or operate exhaust steam-heating systems.

The new Cochrane steam stack and cut-out valve heater and receiver is described, and numerous illustrations show how it is connected to various exhaust steam-heating systems.

BULLETIN S-77 on steam consumption and friction losses of Rice & Sargent Corliss engines gives data regarding compound-condensing and noncondensing and simple noncondensing engines. Steam consumptions as low as 18.33 pounds per indicated horsepower-hour are shown on a noncondensing compound engine at 150 pounds pressure with saturated steam, showing an efficiency of 79.2 per cent. in the use of steam. On condensing compound engines, at 150 pounds pressure, the steam consumptions run as low as 12.1 pounds, and on a noncondensing simple engine at 149 pounds pressure the steam consumption is shown to have been 20.98 pounds. The friction-load indicated horsepower runs as low as 3.8 per cent.

on a compound and 3.6 per cent. on a simple engine, while the mechanical efficiency at full load runs as high as 98½ per cent. The tests to determine these results were made by engineers such as Prof. D. S. Jacobus, George H. Barrus and others, in all cases representing the purchasers of the engine.

PERSONAL

D. M. Forker, formerly with the Republic Iron and Steel Company, Youngstown, O., has been elected vice-president of the D. T. Williams Valve Company, Cincinnati, O.

The Elliott Company and the Liberty Manufacturing Company, of Pittsburg, Penn., announce that Herbert E. Stone has been appointed manager of their New England office, 102 High street, Boston, Mass.

Samuel M. Hildreth has been elected secretary and general sales manager of the Ideal Automatic Manufacturing Company, manufacturers of controlling valves, with officers at 125 Watts street, New York City.

Albert E. Guy, who for the last six years has been at the head of the engineering department of the De Laval Steam Turbine Company, of Trenton, N. J., has resigned that position in order to head a company which will manufacture and place upon the market the Guy centrifugal pump. Mr. Guy has had a wide experience in the engineering field, not only with a number of the more prominent corporations but also in the Bureau of Steam Engineering of the Navy Department. For the last four years Mr. Guy has given personal attention to the centrifugal-pump department of the De Laval company, during which time he has made a number of important discoveries in this branch of hydraulic engineering, all of which will be embodied in the designs of new pumps which he intends to put upon the market. The title of Mr. Guy's new company is the Standard Pump Company, and its headquarters are at 30 Church street, New York City.

BOOKS RECEIVED

NOTES ON DRAWING. By Horace P. Fry. University of Pennsylvania, Philadelphia, Penn. Cloth; 57 pages, 6¼x9¼ inches; 34 illustrations; indexed.

POWER GAS AND THE GAS PRODUCER. By J. C. Miller. Published by Popular Mechanics Company, Chicago, Ill. Cloth; 184 pages, 5½x8¼ inches; 18 illustrations. Price, $1.

NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c. each. Address the Commissioner of Patents, Washington, D. C.

PRIME MOVERS

INTERNAL COMBUSTION ENGINE. Charles W. Foster, New Haven, Conn. 972,841.

EXPLOSION ENGINE. William Anthony Jones, West New Brighton, N. Y. 972,869.

FLUID-PRESSURE TURBINE. Charles Algernon Parsons, Newcastle-upon-Tyne, England. 972,908.

INTERNAL COMBUSTION ENGINE. Martin L. Williams, South Bend, Ind. 972,966.

HYDRAULIC MOTOR. Paul Andersen, Pinole, Cal. 972,981.

HOISTING ENGINE. John Welker Freeman, Joplin, Mo. 973,028.

INTERNAL COMBUSTION ENGINE. Walter J. O. Johnson, Chicago, Ill. 973,048.

ROTARY ENGINE. Christian F. Paul, Jr., Peekskill, N. Y., assignor of one-tenth to Kenneth Mott, Peekskill, N. Y. 973,064.

GAS ENGINE. John M. Kroyer, Stockton, Cal., assignor to Samson Iron Works, Stockton, Cal., a Corporation. 973,118.

INTERNAL COMBUSTION ENGINE. Charles H. Sergeant, Bridgeport, Conn. 973,140.

CURRENT MOTOR. Albert Vestal and Delbert F. Bennett, Redding, Cal. 973,241.

INTERNAL COMBUSTION ENGINE. Chas. Elisha Fogg, Kennett Square, Penn. 973,268.

FLUID-PRESSURE HEAT ENGINE. Jean Molas, London, England. 973,289.

OSCILLATING MOTOR. Harry A. Adams, Reading, Penn., assignor, by mesne assignments, to Edwin E. Pryor, Reading, Penn. 973,400.

WATER WHEEL. Zachariah C. Ferris, Caldor, Cal. 973,419.

BOILERS, FURNACES AND GAS PRODUCERS

GRATE BAR. Anderson Wilderspin, Grand Saline, Tex., assignor of one-half to David C. Earnest, Dallas, Tex. 972,965.

OIL-BURNING STEAM BOILER. William A. Rogers, Los Angeles, Cal., assignor to Charles A. Hammel, Los Angeles, Cal. 973,138.

METHOD OF PRODUCING GAS. Edmund G. Jewett, Bellingham, Wash. 972,864.

LIQUID FUEL BURNER. Hooker Shapel, Iola, Kas. 972,931.

STEAM BOILER. Charles A. Hammel, Los Angeles, Cal. 973,111.

FURNACE. Hanna Haas, New York, N. Y. 973,273.

POWER PLANT AUXILIARIES AND APPLIANCES

SPARK PLUG. George Baehr, McKeesport, Penn. 972,798.

SPEED-REGULATING MECHANISM. John C. Carpenter, Houston Heights, Texas. 972,815.

DEVICE FOR INCREASING THE DRAFT OF CHIMNEYS AND FOR OBTAINING DRAFT WITH BAD CHIMNEYS. Guillaume Geessels, Brussels, Belgium. 972,847.

FEED-WATER HEATER AND PURIFIER. Thomas J. Cookson, Cincinnati, Ohio. 972,824.

HOSE COUPLING. John I. Creveling, New York, N. Y., assignor to Safety Car Heating and Lighting Company, a Corporation of New Jersey. 972,829.

PRESSURE-REGULATED VALVE. Alva Thrift Edmonson, Chicago, Ill. 973,016.

VALVE GEAR FOR ENGINES. Charles F. Prescott, Philadelphia, Penn. 973,137.

CARBURETER VALVE. Nicholas P. Mader, Sun Prairie, Wis. 973,056.

MIXER. Micholas P. Mader, Sun Prairie, Wis. 973,057.

DEVICE FOR CLEANING BOILER CROWN SHEETS. William D. Randall, Monett, Mo. 973,059.

GAGE COCK. Jamieson V. Scaife, McComb, Miss. 973,074.

VALVE. Oliver Schlemmer, Cincinnati, Ohio. 973,075.

FLUID-PRESSURE GOVERNOR. George C. Hicks, Jr., and Ralph C. Enyart, Connersville, Ind., assignors to the P. H. & F. M. Roots Company, Connersville, Ind. 973,197.

FLEXIBLE METALLIC TUBING. Henry Tideman, Menominee, Mich., assignor of one-half to James Wolff, Chicago, Ill. 973,238.

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., George Westinghouse; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., W. W. Freeman, Brooklyn, N. Y.; sec., T. C. Martin, 31 West Thirty-ninth St., New York.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U. S. N.; sec. and treas., Lieutenant Henry C. Dinger, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railroad, Cleveland, O. Next meeting to be held in Boston, Mass.

WESTERN SOCIETY OF ENGINEERS

Pres., J. W. Alvord; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., E. K. Morse; sec., E. K. Hiles, Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., Dugald C. Jackson; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

Pres., Prof. J. D. Hoffman; sec., William M. Mackay, P. O. Box 1818, New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., Carl S. Pearse, Denver, Colo.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Cincinnati, Ohio.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, John Cope; sec., J. U. Bunce, Hotel Statler, Buffalo, N. Y. Next annual meeting in Philadelphia, Penn., week commencing Monday, August 7, 1911.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next meeting at Philadelphia, June, 1911.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting, St. Louis, Mo., January 16-21, 1911.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; sec. and treas., Prof. F. E. Sanborn, Ohio State University, Columbus, Ohio.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. N. Lucas; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Omaha, Neb., May, 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., J. G. Hannahan, Chicago, Ill. Next meeting at St. Paul, Minn., September, 1911.

NATIONAL DISTRICT HEATING ASSOCIATION

Pres., G. W. Wright, Baltimore, Md.; sec. and treas., D. L. Gaskill, Greenville, O.

A Homemade Planimeter

By Howard H. Bliss

A planimeter which can be constructed with a few pieces of wood, a small steel wheel and a broken thermometer tube. A demonstration of the principle upon which it is based.

Many cases arise in the experience of people connected with engineering in which they find it desirable to know the area of irregular figures, such as indicator diagrams from a steam or gas engine, or maps of irregular pieces of ground, contour lines, etc. These areas can often be measured roughly by dividing them into triangles and parallelograms, measuring the dimensions of these and computing their size. However, in order to get an accurate measurement of irregular figures it is necessary to make use of an instrument called the planimeter.

Planimeters can be bought at prices ranging from ten or fifteen dollars upward. Anyone who is handy with tools can construct one which will cost nothing but the labor of making it. The writer owns one made in spare minutes which does the work required with an error of less than 1 per cent. This instrument is of an older type than the planimeters sold now, but it works practically as well and was considerably easier to construct. It is made chiefly of wood. Fig. 1 shows the general construction. At Q is a point designed to stick into the paper or drawing board and hold that end of the arm $Q\,Y$ so that the arm can sweep around in a circle. At Y is a block of wood held to the arm $Q\,Y$ by a screw pointing upward which turns freely in the arm and allows the block and the rest of the planimeter to swing about the screw as an axis. The rod R is a glass thermometer tube whose graduations are cut into the glass. Upon this slides the steel wheel W, which is shown in detail in Fig. 2 and which has a fairly sharp edge so that it does not slip over the paper when R is drawn through it by the motion of the instrument. The wooden stick $Y\,T$, called the "tracing arm," fits rather tightly into a groove in the top of the block Y. This groove is at right angles to the glass rod R, which fits into a hole bored through the block about half way between the top and bottom. At T is the "tracer," simply a nail with its point smoothed, which reaches down to the level of the paper, and which, when the planimeter is in use, is made to follow the outline of the diagram to be measured.

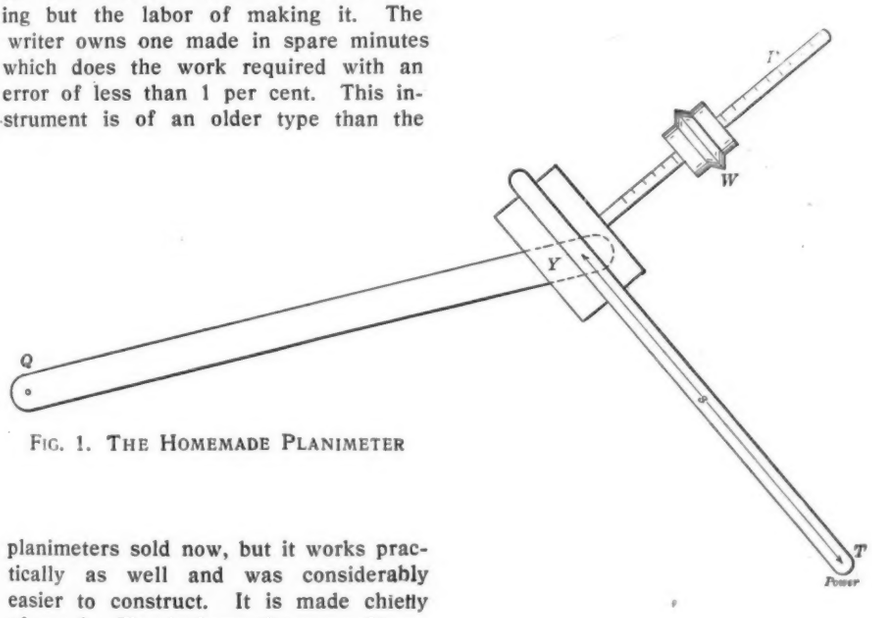


FIG. 1. THE HOMEMADE PLANIMETER

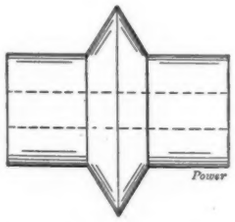


FIG. 2. THE TRACING WHEEL

The whole operation of measurement is extremely simple. The point Q is stuck into the paper at some convenient place, the wheel W is set by hand at the zero mark on the thermometer tube, the point T is run around the figure in a clockwise direction, finishing at the starting point, and then the area of the drawing is read off as the distance the wheel has moved on rod R, each scratch on the glass being read as a square inch.

The proofs and explanation of the action of the planimeter as given in textbooks either depend upon the calculus or are made very long and intricate in the effort to escape higher mathematics. The proof given below, however, is quite simple, and to understand it does not require any mathematical knowledge beyond arithmetic. It is practically the proof offered by the calculus with the technical parts simplified.

In Fig. 3 consider the tracing arm as detached from the rest of the instrument and occupying the position $T\,Y$. Let the arm be moved to the position $T'\,Y'$, the tracer T following all the time the lower line of the figure A, while the other end follows the arc $Y\,Y'$. In its travel the whole arm sweeps over the area $A + B$ (that is, it moves over every spot in both of the spaces A and B), swinging about to accommodate the curves of the figure, as shown by the dash-and-dot line. Then, let the arm move back to its first place, keeping the tracer now on the upper side of the figure A and the other end still on the circular arc. Thus it sweeps over the area B, but in the opposite direction; let us call it negatively. Then, during the whole trip, the resulting positive area swept over is simply A, for B is canceled by going back over it in the opposite way.

Having proved that the positive area swept over by the arm in its travel is the same as the area of the figure followed by the tracer, we have next to consider how we may measure what area is swept over by a stick moving sidewise, as this has done. This is best got at by considering a very small portion of its motion, as shown in Fig. 4, from a position $Y_1\,T_1$ to another $Y_2\,T_2$. Assuming

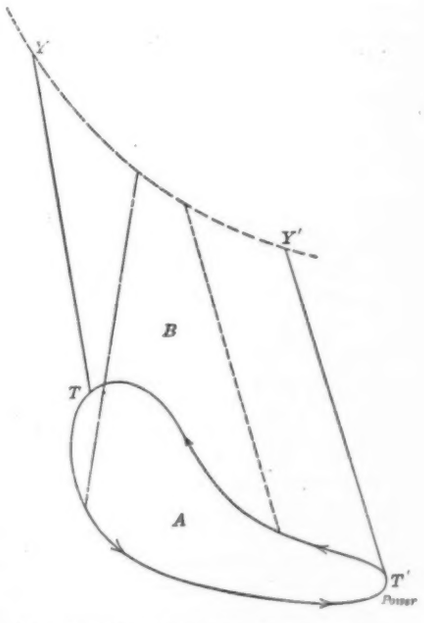


FIG. 3. SHOWING THE TRAVEL OF THE TRACING ARM

that the arm travels straight over to $Y_2 T_2$, slips lengthwise to $Y_3 T_3$, and swings to its last position, the small area swept over is the sum of the little rectangle (whose size is $s\,x$) and the "pie-shape" piece adjoining. The whole area covered by any motion of the arm will be the sum of an infinite number of these microscopic rectangles and "pie-shape" pieces.

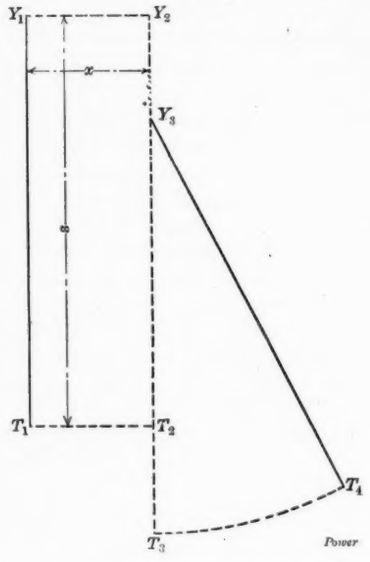


FIG. 4. DIAGRAM OF METHOD OF PLANIMETER OPERATION

The fact that the actual motion from $Y_1 T_1$ to $Y_3 T_4$ may not have occurred by the three simple shifts imagined is of no importance, since the positions may be taken infinitely close to each other and hence any error involved would reduce to zero. Now, the sum of all of the little rectangles will be the area obtained by multiplying s, the length of the tracing arm, by the sum of all the distances the arm has moved perpendicular to itself. The glass rod mentioned in the description will have slipped just that distance through the little wheel, slipping to the right when the tracing arm moves in that, the positive, direction, and to the left when the arm moves backward in the negative direction. It should be noted that the swinging of the tracing arm over the small "pie-shape" pieces will not cause any slip of the glass rod through the wheel. However, the sum of these pieces will be zero, for just as many are made with the arm swinging backward as forward, and hence the negative ones will balance the positive ones by the time the arm gets back to its original position, for, of course, the arm must swing just as much backward as forward in order to point in the same direction when it gets through as when it started.

It has been proved, first, that the total positive area swept over by the arm in its journey around and back to the starting point is A, and, second, that the area swept over is the product of the length of the arm and the total distance which it has moved perpendicular to itself, or the distance the rod has slipped through its wheel. Hence, A, the area of the figure around which the tracer has run, will be equal to the reading on the glass rod multiplied by the length of the tracing arm. By properly adjusting the length of the tracing arm the divisions of the glass rod may be made equivalent to the area passed over; if the marks are ⅛ inch apart, a tracing arm 8 inches long will give the result that a reading of three divisions on the glass will mean an area of three square inches passed around by the tracer.

In all that has preceded it has been assumed that the other end Y of the tracing arm has gone forward and back along its circular path. That is the fact in almost all cases where the planimeter is used, such as in scaling off indicator diagrams and similar small areas. But, there come times when it is necessary to measure such large areas that the tracer cannot reach all points on the boundary at one set up unless the fixed point Q is placed within the figure, and that will result in the travel of Y around a circle to its starting point, without going backward to it. If there is a right angle between $Q\,Y$ and $Y\,T$, Fig. 1, all the way round, which means that T will trace a circle around Q, there will be no motion of the wheel along the rod. The circle so traced by T is called the "zero circle."

To measure an area larger than the zero circle, as shown in Fig. 5, the planimeter is set with point Q near the middle of the figure. Suppose the tracer to start at G on the boundary and move around, as shown by the arrows, to the point J, which is very close to G. The reading of the instrument at this point

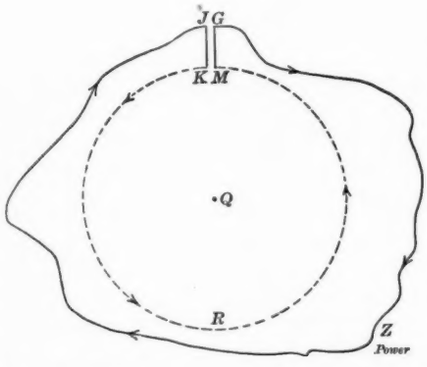


FIG. 5. DIAGRAM OF AREA LARGER THAN THE ZERO CIRCLE

can be proved to be the area included between the outer border and the zero circle (shown dotted), thus: If the tracer were brought toward the center along the line $J\,K$, a slight change would be made in the reading of the planimeter. Then if the tracer followed the zero circle around according to the arrows to point M, no change would be made in the reading. Moving from M to G would be practically the same as going back along $K\,J$, and the change in the reading would cancel the change brought about by the motion from J to K. The outline of the figure $G\,Z\,J\,K\,R\,M\,G$ would then be traced and the point Y would have returned to its original place along the path it followed in the first part of its journey. Hence, the reading on the recording apparatus would be this area, and it would be the same reading that was obtained at J. Of course, the distance between J and G need not be more than a millionth of a hair's breadth, which means that we really run the tracer clear around to the starting point, in practice.

Therefore, to find the area of any large figure, add the area of the zero circle to the reading of the recording mechanism. It sometimes happens that part or all of the boundary of the large figure lies within the zero circle, but it can be shown that every time the reading is to be added to the area of the zero circle, even though the reading should be negative, which will be the case when the area is smaller than the zero circle.

To find the area of the zero circle of any planimeter all that need be done is to trace out a circle larger than the zero circle and subtract from the computed area of the large figure the area read on the recorder. The easiest way to trace such a circle is to punch two holes through a narrow strip of paper near the ends, stick the pin at Q through one hole into the drawing board and stick the tracer through the other. By steadily pulling outward on the tracer the paper is kept tight and a perfect circle may be run around without the trouble of following a line with the tracing point.

Planimeters of more modern types dispense with the rod R, Fig. 1, and its sharp-edged wheel, substituting a differently shaped wheel placed under or beside the tracing arm with its spindle parallel to the arm. The distance moved by the arm parallel to itself is equal to the amount which the wheel rolls, and this is read off by means of marks cut into the rim of the wheel and a vernier or pointer attached to the arm. A disk geared to the wheel keeps count of the number of revolutions. The principle is exactly the same as that upon which the homely wooden instrument, here described, is based, for the sidewise travel of the arm is registered and the endwise motion causes no change in the reading.

A modification of this later type is the Coffin planimeter, which is much used in measuring indicator diagrams. The arm $Q\,Y$ is left off and the end Y of the tracing arm is guided in a straight line by a pin which follows a groove in the drawing board. The principle is still the same, for the fact that Y travels in a straight line instead of an arc makes no difference in the proof.